

" You can observe a lot, just by watching."

Yogi Berra



PACIFICONSM 2021

ARRL Pacific Division Ham Radio Convention
Produced by the Mount Diablo Amateur Radio Club



PACIFICONSM 2021

San Ramon Marriott
2600 Bishop Drive
San Ramon CA 94583



IN PERSON!

Friday through Sunday
Oct. 15-17, 2021

Portland Amateur Radio Club



Focus on antennas for Limited (Space, Time, Budget)

Tom Schiller, N6BT

30 years developing and manufacturing antennas

Founder Force 12, Inc. (1991-2008) and Next Generation Antennas (2010-2021+)

Developed first trapless tri-band Yagi, the C-3, Elite-Strike-Magnum Force Yagis, XR series 3 & 5 band

Yagis including the C-49XR, 50-ohm Yagis, 80/75 Yagis/dipoles, 160mtr rotatable dipoles and more

ZR / Sigma / EV / Bravo / and VOR verticals

Shipped >27,000 antennas, mostly HF Yagis

Several patents related to wireless communications

Antenna research, including flying drones through antenna patterns since 2014

Author, Array of Light and published articles (QST and NCJ)

Speaker at Pacificon Antenna Forum >25 years

Co-founder, Team Vertical – set 24 World Records

A.R.R.L. Life Member (licensed 1959)

CWops #281, 10-10 Int'l #4629

Contester, DXpeditions, World and regional Records

Co-founder, NCJ (National Contest Journal)



Limited Space:

Visual Restrictions
or

simply a “no antennas” mandate

directly impact the most influential component of a radio station:

the antenna

Limited Space can also apply to DXpeditions, mobile, portable, SOTA, etc.

When deciding on an antenna to purchase,
we depend mostly on the
manufacturer/seller's claims.

We also seek out anecdotal comments
from friends
and
on the Internet.

Expectations



Anticipated
Experience



There is no free lunch

Basic steps to assist in deciding on your antenna selections:

- ___1. Available space (and type i.e. ground, roof, etc.)
- ___2. Bands (practical for limitations)
- ___3. Location
- ___4. Equipment
- ___5. Installation (time) + Maintenance
- ___6. Budget

How can you evaluate an antenna?

What equipment is used as an indicator of how well an antenna is “working?”

A “low VSWR” became a leading indicator of whether or not a particular antenna was a good one.



The VSWR matched to the coveted 1:1.

It must be a killer antenna.

“I have never let my schooling interfere with my education.”

Mark Twain

What is the purpose of the antenna?

1. Get on the air to work someone, anyone.
2. Be able to work locals and friends.
3. Chase DX.

What is a common issue for all 3?

length

as in wavelength

This is probably the major factor to be considered,
unless there is a specific prohibition on outdoor antennas,
then there are other obvious issues to consider.

What kind of lengths are we looking at?

Length depends on the band(s) we are interested in using.

A half-wave in free space,
is calculated using
 $492/f$ (MHz)

$\frac{1}{2}$ wavelength dipole

	Free space	Wire approx 468/f
10 mtrs =	17.4'	16.6'
12 mtrs =	19.7'	18.8'
15 mtrs =	23.2'	22.1'
17 mtrs =	27.1'	25.9'
20 mtrs =	34.6'	33.0'
30 mtrs =	48.7'	46.3'
40 mtrs =	69.2'	66.0'
80 mtrs =	129.5'	123.1'
160 mtrs =	269.5'	260.0'

Why include free space length?

Useful for spacing phased elements, as
they are coupling through air, not through a
physical conductor (e.g. wire).

For a given small area to work with, which bands are “reasonable” to consider?

	Free space	Wire approx 468/f	
10 mtrs =	17.4'	16.6'	
12 mtrs =	19.7'	18.8'	
15 mtrs =	23.2'	22.1'	
17 mtrs =	27.1'	25.9'	←
20 mtrs =	34.6'	33.0'	←
30 mtrs =	48.7'	46.3'	
40 mtrs =	69.2'	66.0'	←
80 mtrs =	129.5'	123.1'	
160 mtrs =	269.5'	260.0'	

With our current sunspot conditions, the best choices are 20, maybe 17, for daytime operating and 40 for nighttime and nets.

one octave
means doubling or halving the frequency

10 to 20
20 to 40
40 to 80
80 to 160

why is this important?

A (fixed length) antenna for a particular band can be loaded for one octave lower while maintaining good efficiency.

The length for the lower frequency is only half what it should be, which makes the selection of the loading device very important.

10 meter dipole is ~16.5'

and the octave lower 20 meter dipole should be ~33'

Now you want to also use it on 40?

the 2 octave lower 40 meter dipole wants "to see" ~66',
but all we have is 16.5'

which is $\frac{1}{4}$ size.

Want it to work on 80/75?
it will be $\frac{1}{8}$ size

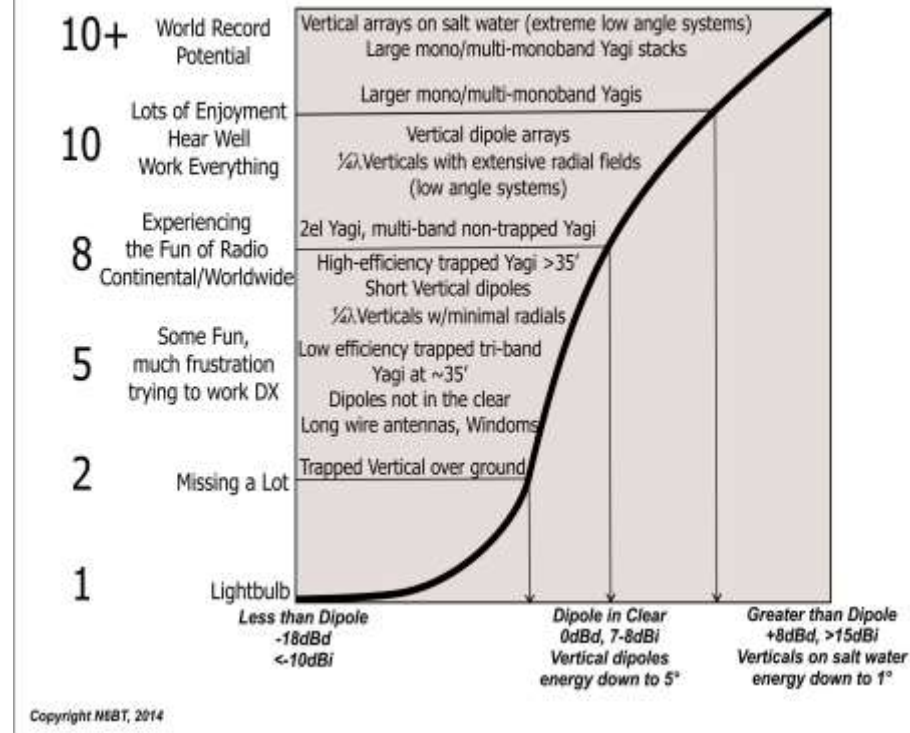
but

We can make everything work
to some degree.

Main concerns for electrically short antennas are:

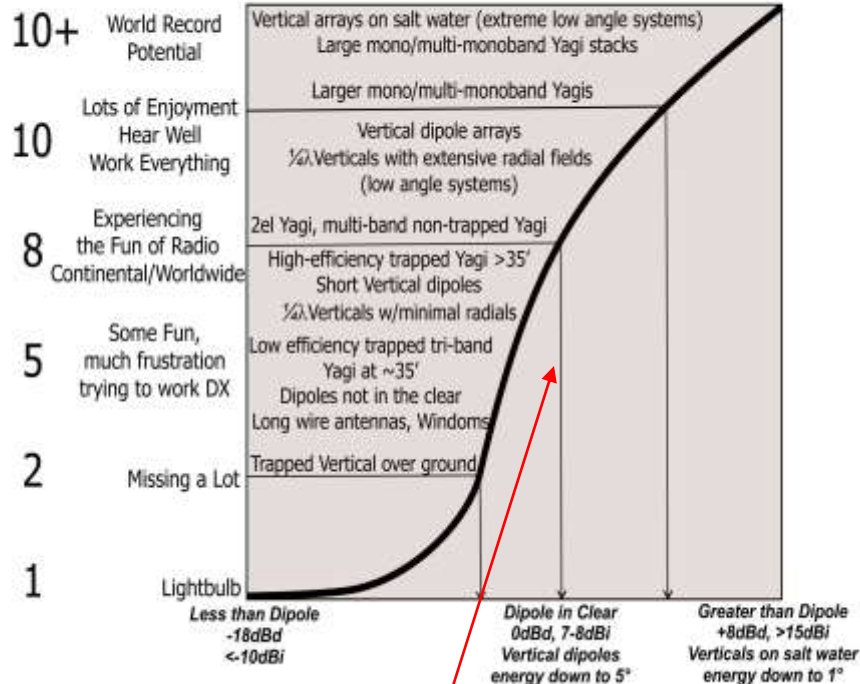
- ___matching the (probably) very low feed point impedance (or, if end-fed, probably very high feed impedance);
- ____efficiency due to the electrically short/small size and components used
- _____VSWR operating bandwidth – restricts our TX movement
can still hear (although sigs are down); TX won't like the mismatch

Performance Rating for 20-10 Meter Antennas



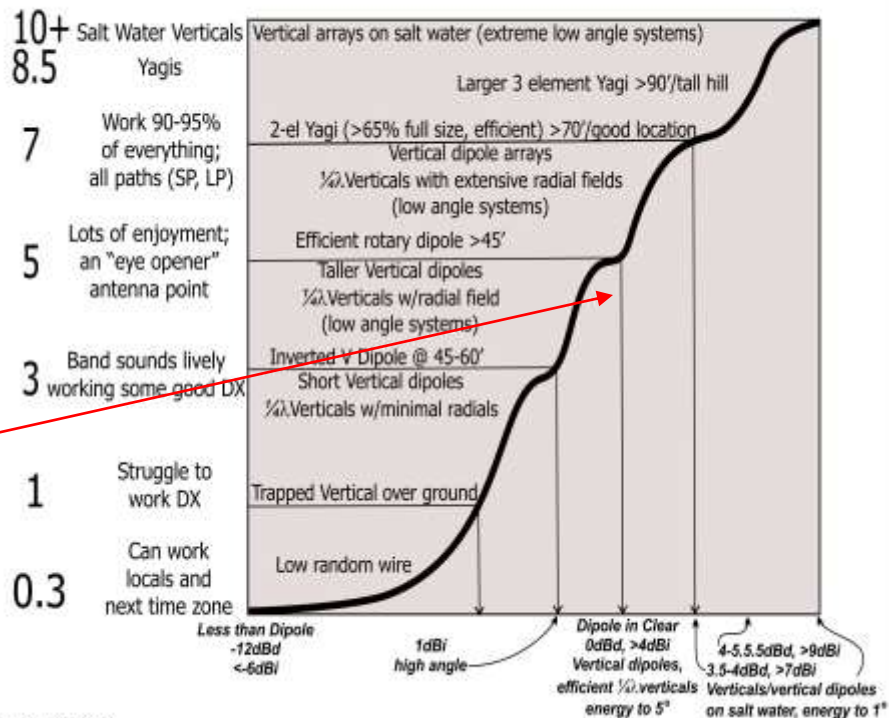
Enjoyment of radio to antenna performance

Performance Rating for 20-10 Meter Antennas



Copyright N8BT, 2014

Performance Rating for 40 Meter Antennas



Copyright N8BT, 2014

These charts indicate that a dipole or a good vertical will provide lots of enjoyment from radio.

Nothing particularly fancy,
only efficient.

Why is it that some think their (compromised) antenna works really well?

Example path

Let's assign that it takes 20dB of path energy to communicate from A to B.



If antenna A has 10dB and antenna B has 10dB, the path is completed.



If antenna A has 8dB and antenna B has 10dB, the path *is not* completed.

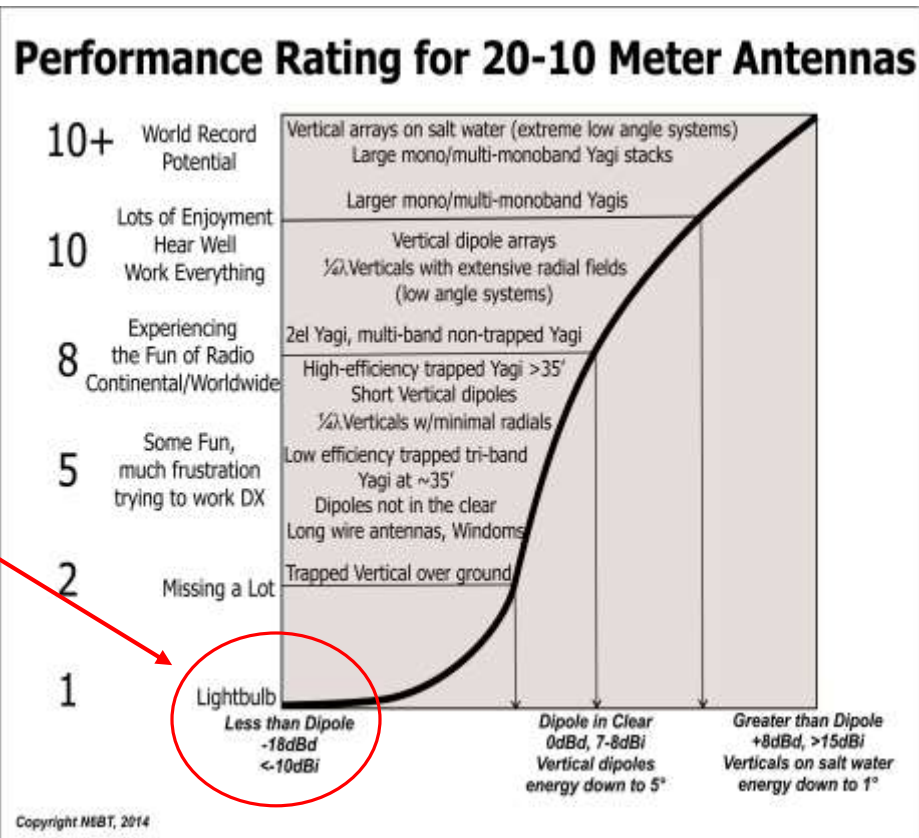


If antenna A has 8dB and antenna B has 12dB, the path *is* completed.



Answer – there are enough stations with larger antennas that make up the “missing dBs” to enable a QSO.

They do the “heavy lifting”, so to speak.



-18dBd Dean, N6BV, asked if I had ever done an empirical test. Well, no, we hadn't, so we did:
full size 10 meter dipole to a lightbulb and yes, it was just about -18dBd

The “Illuminator”



28 countries and W.A.C. in one weekend

120 watts (ARRL DX CW)

QST July, 2000

3 element phased light bulb array

(select any 2 elements in phased broadside)

34 countries and W.A.C. in one weekend

1,200 watts (ARRL DX SSB)

estimated gain is 3dBslb



Used 300 watt bulbs; blew them all out, but it worked the same.

Although we worked a fair number of countries,
it was only because there were enough stations with
large/effective antennas that could hear us.
They made the QSO's possible.

*Needed Africa on CW → waited until ZD8Z came on:
very large antenna and a good operator (N6TJ).*



A few basics.....

When we have limited physical “something”, it could be:

___limited horizontal length,

____limited vertical height,

_____visual limitations.

...and we also might -

___be all inside (aaarghh),

____have a balcony (an asset),

_____have access to ground (an asset).

My “off the top” thoughts for an antenna:

___be all inside _____magnetic loop

___have a balcony _____mag loop, compressed vertical or dipole

___have access to the ground _____many more options

The magnetic loop is a low profile antenna you can make, or purchase.

They have been around almost a hundred years.

Many were built back in the early 90's and
seem to be gaining popularity today → small, easy to handle, multi-band

Main issues with magnetic loops?

Very narrow VSWR operating bandwidth (a few kHz)

Power handling

Many/most are limited to around 15-25 watts.
The voltages opposite the feed point are extremely high

My (limited) experience is that magnetic antennas are less sensitive to immediate surroundings
and, based on many tests of our ZR vertical antenna, can perform well inside buildings.



ICOM AL-705 40-10M Magnetic Loop Antenna

40-10 meters 20 watts SSB and 10 CW/Digital

Retail \$230



MFJ mag loops available in several models, including down to 40 meters and still a small footprint of about 3' diameter.

150 watts

→ Notice the large enclosure

Retail \$560

38

The difference is mainly the capacitor to handle higher power



From an old AEA that could take some power
(150 w);
motor drive tuning



Wide spacing on butterfly capacitor plates to handle high voltage



A surplus vacuum capacitor will also work well.
(few hundred \$\$, plus mount, drive unit, etc.)

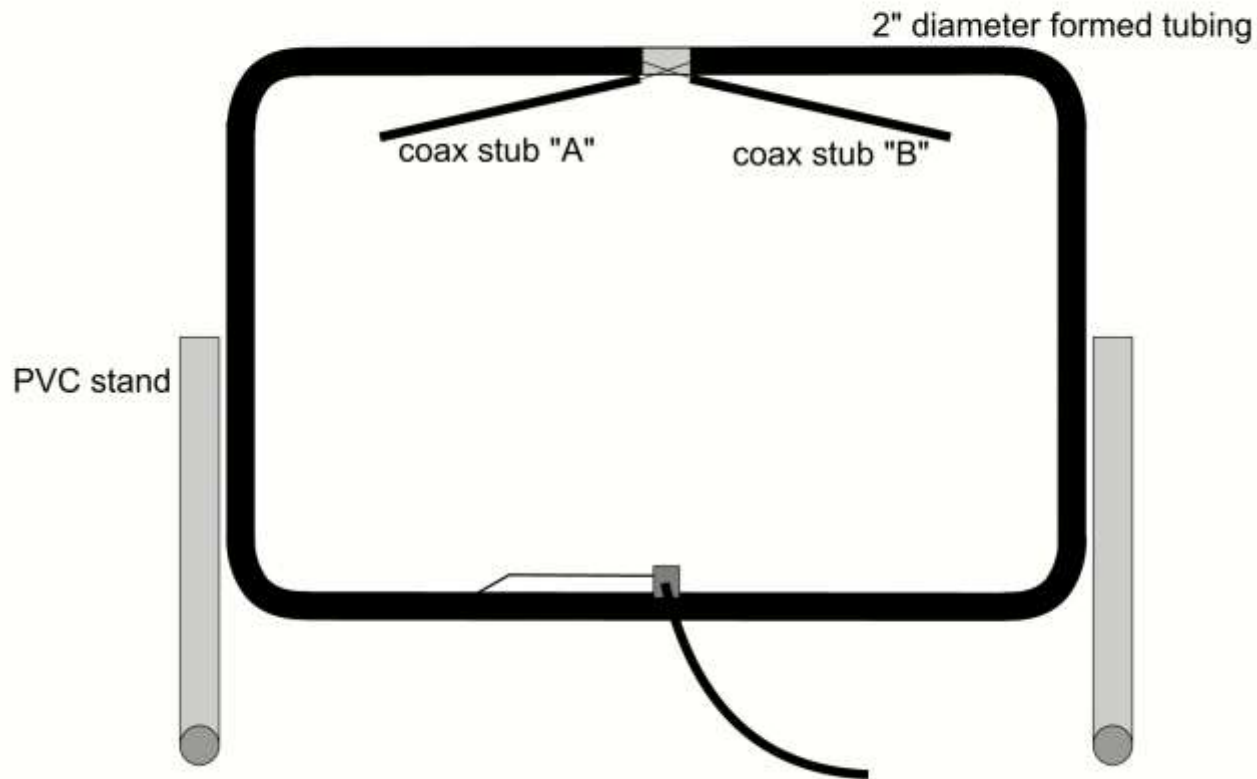
If we want:

- a) 40 meters
- b) broader banded than a 3' loop
- c) handle at least 100 watts w/o vacuum caps
- d) not too tall, or can be “made lower” when not in use.

well-designed magnetic loop.

You can make this one...

7' x 9' Magnetic T/R Loop



This can rotate in the stand to horizontal when not in use.

overall design and dual coax stub tuning technique by Ken Hirschberg, K6HPX

(fixed frequency set by adjusting the stub lengths)

**Magnetic Loop Data
for Loops made of
2" diameter aluminum tube
with formed corners.**

	6'x6' square	3' dia loop
Surface area	36 sqft	7.1 sqft
Circumference	36'	9.4'

Low Profile	160	80	40	30	20
6' x 6'	recv	2.8%	13%	37%	50%
6' x 8'	recv	3.2	16	32	*
7' x 9'	recv	5	25	35	*
6' x 12'	recv	5.4	25	*	
6' x 18'	recv	7.1	*		
Max Size	160	80	40	30	20
9' x 9'	recv	6%	27%	50%	*
12' x 12'	3%	12	50	*	
22' x 22'	10	45	*		
44' x 44'	40	*			

Efficiency	Loss (dB)	Loss (S-Units)**	Utility
100%	0	0	Excellent
50	-3	½	Excellent
25	-6	1	Very Good
12.5	-9	1 ½	Good
6.25	-12	2	Good
3.13	-15	2 ½	Usable
1.5	-18	3	Usable

Calculations by Ken Hirschberg, K6HPX

* too large

** S-Units presuming 6dB/unit, some are 4 or 5dB/S-unit

Ciro Mazzoni

Automatic Magnetic Loop Antennas “BABY”

40-10 meters

Auto or Man. Tune

incl. ATU 2.0 + Keypad

450W 6.6-21.9 MHz

1kW 22-29.8 MHz

Aluminum, 39.8 in. dia. 26.5 lbs.

Loop is 2" diameter aluminum tube

~\$2100 + options (should use a rotator)



Ciro Mazzoni

Automatic Magnetic Loop Antennas “MIDI”

80-20 meters

Auto or Man. Tune

incl. ATU 2.0 + Keypad

300W 3.5-7.9 MHz

800W 8.0-14.5 MHz

Aluminum, 78.7 in. dia. 44.1 lbs.

Loop is 2" diameter aluminum tube

~\$2500 + options (should use a rotator)





“Stealth Loop”

40-10 meters, Auto/Man. Tune w/incl. ATU 2.0+Keypad

125 W, 6.6-29.8 MHz

Powder Coat Alum., 54 x 20 x10 in., 15.4 lbs.

Sits on a metal plate or screen ~5'x3' (feet used to adjust the VSWR)

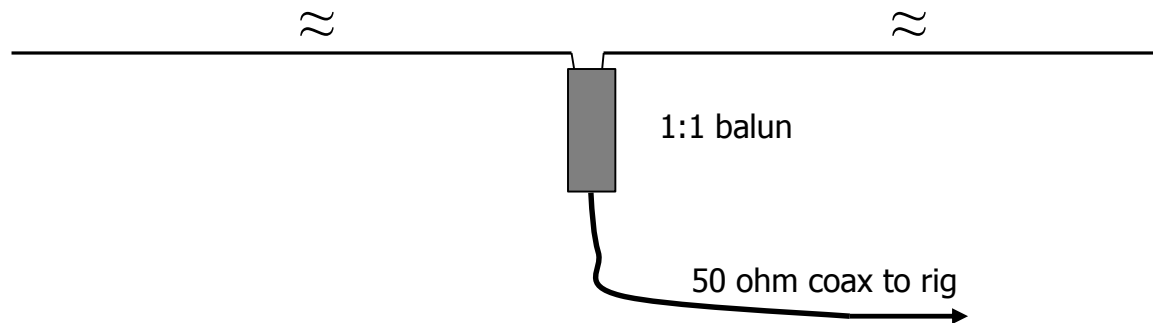
~\$1800 + options

What about simply putting up a wire – something?

What is the most efficient, simple antenna?

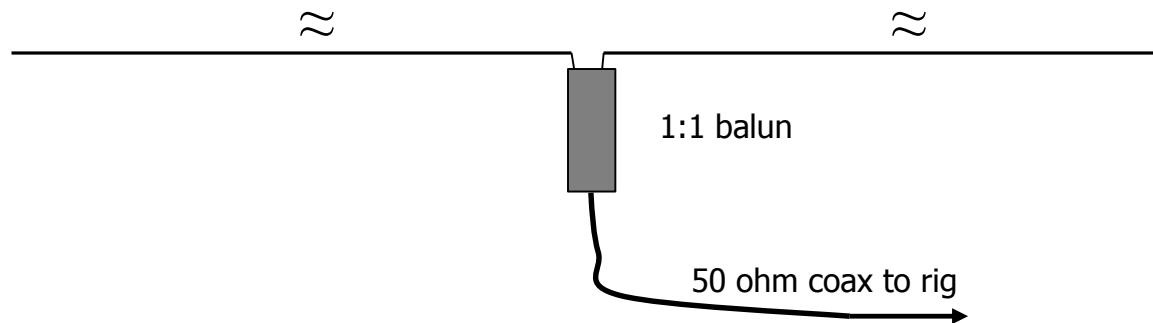
What is the most efficient, simple antenna?

A $1/2\lambda$ dipole (equal $1/4\lambda$ halves), fed at the center



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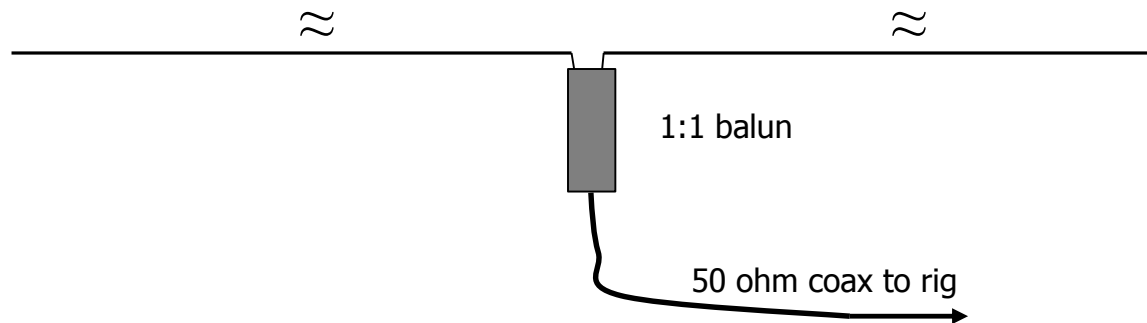
A $1/2\lambda$ dipole (equal $1/4\lambda$ halves), fed at the center



What is the most efficient, simple, multi-band antenna?

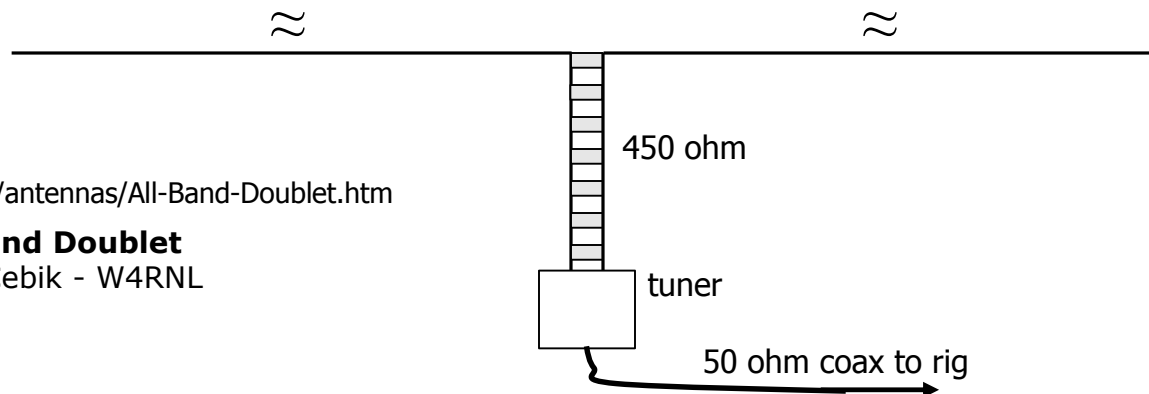
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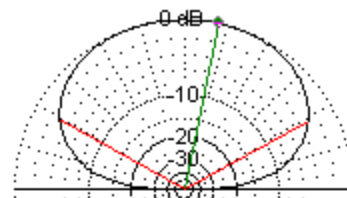
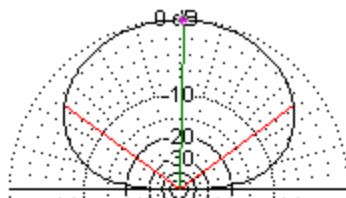
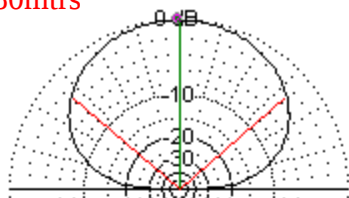
A "doublet" (equal *length* halves), fed at the center with open-wire line



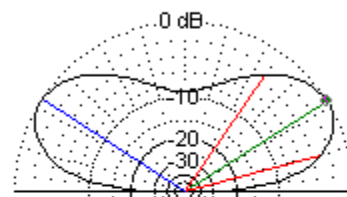
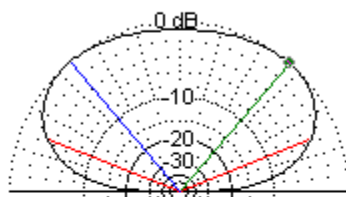
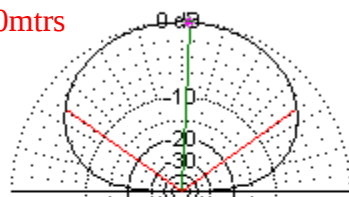
<http://webclass.org/k5ijb/antennas/All-Band-Doublet.htm>

All-Band Doublet
L. B. Cebik - W4RNL

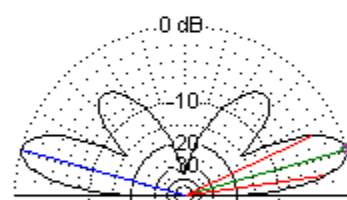
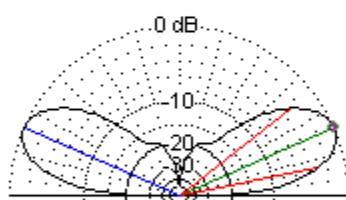
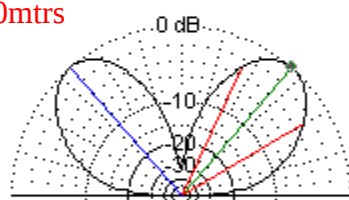
80mtrs



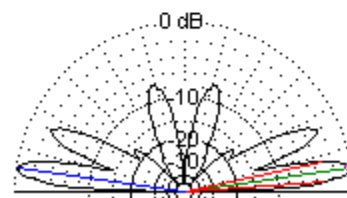
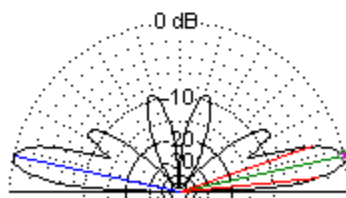
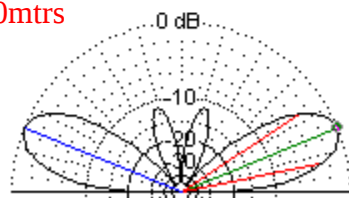
40mtrs



20mtrs



10mtrs



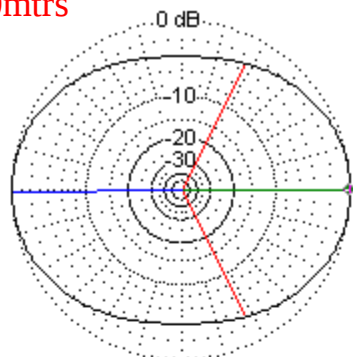
20'

40'

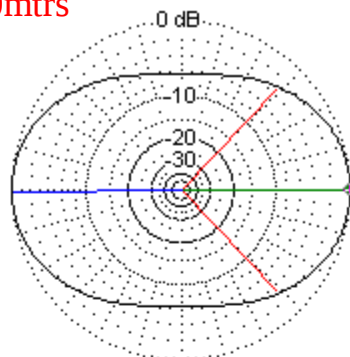
60'

135' doublet antenna at various heights above ground
(same elevation patterns for a dipole)

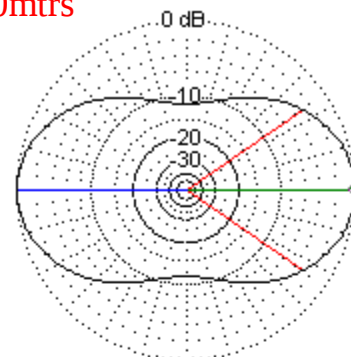
80mtrs



60mtrs

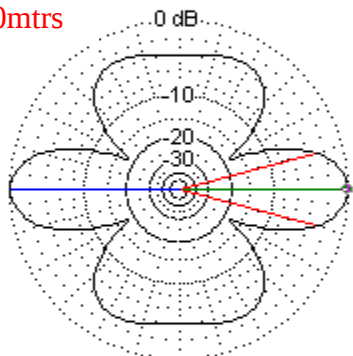


40mtrs

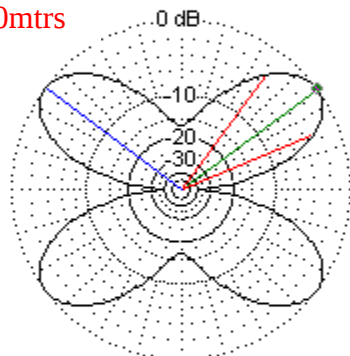


Note: These three patterns use an arbitrary 45-degree elevation angle. See table for the higher actual TO angle.

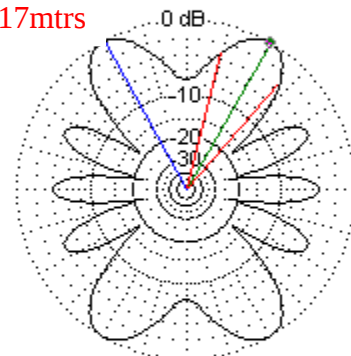
30mtrs



20mtrs

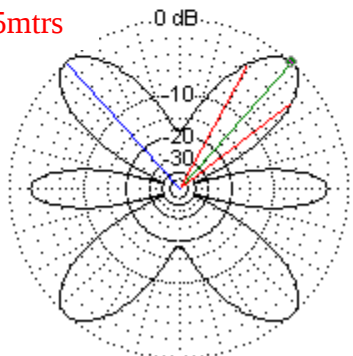


17mtrs

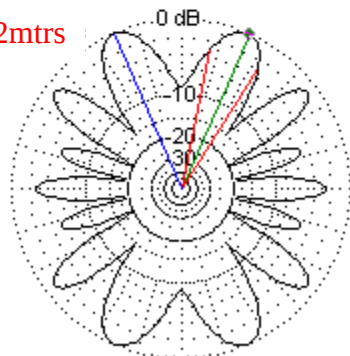


Antenna orientation for all patterns.

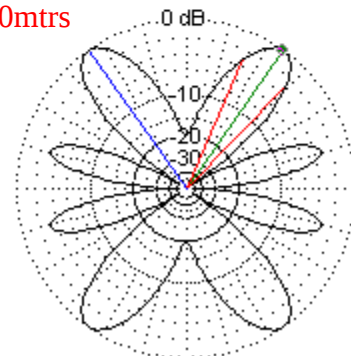
15mtrs



12mtrs



10mtrs



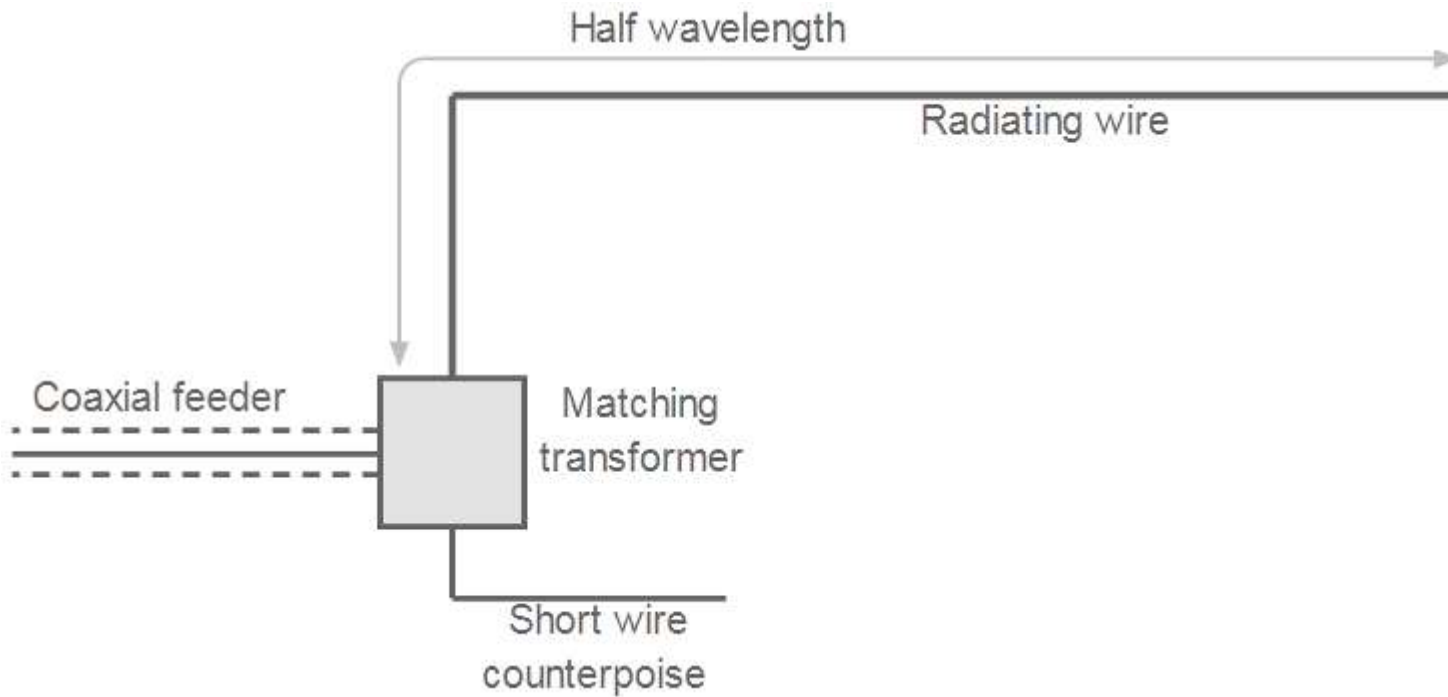
Azimuth patterns for 135' doublet antenna @ 40'
(80/40 patterns are at 45° elevation, others at their TO angle)

The main issue is a horizontal antenna like the dipole/doublet needs height.
This example dipole is at 35' high and for most areas
with restrictions, this is probably not feasible.

A typical take-off angle for a ground-mounted vertical that is
elevated above ground (no ground radials) is about 12° and
lower over very good ground (so says our drones).

Another possible antenna is the EFHW:

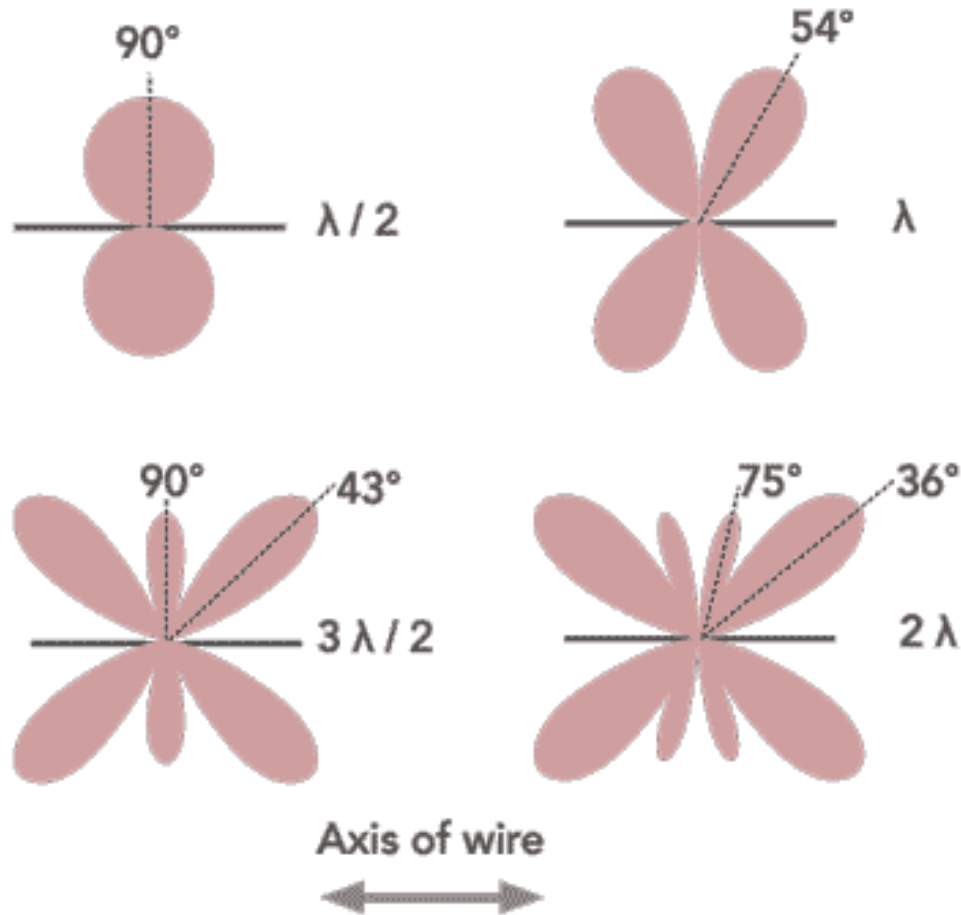
end-fed, half wave



If the EHFW is installed correctly with an elevated far end:

- 1) the pattern will change according to the band on which it operates (the number of $\frac{1}{2}\lambda$'s it uses);
- 2) as a half wave radiator = same way as a half wave dipole (figure 8 pattern, 90° to wire axis);
- 3) as the length increases, the pattern changes with additional lobes forming.

Examples.....



.....depending on frequency of operation, it might or might not perform to your expectations

NOTES on the EFHW:

___The counterpoise is very short/small.

___The “box” contains an impedance matching transformer, usually 49:1 (this is not a balun).

___There is no balun that comes with the antenna – have yet to see one installed.

_____Perhaps the coax feed line is actually a component of the antenna.

Most popular, basic (generally) horizontal antennas:

- a) $\frac{1}{2}$ wave dipole (resonant on a particular band)
- b) doublet, fed with open wire (not necessarily resonant anywhere)
- c) G5RV (102' doublet, specific feeder length – originally 3x20m halfwaves)
- d) ZS6BKW (shorter than G5RV, specific component lengths)
- e) ZS6BKW, Jr. (ZS6BKW with wires bent downwards at half-way points)
- f) Windom (Zepp type, 14% off-center fed with single wire)
- g) Carolina Windom (Windom + 4:1 matching, 22' wire, choke, feed line)
- h) EFHW (end-fed-half-wave)

Commonalities? Differences?

Commonalities:

- a) the patterns are all basically the same for a given height above ground
- b) all need supports to get them elevated (above ground)

Differences:

- a) the dipole does not need a tuner (for its primary band)
- b) all others need a tuner, either at the feed line, or at the rig (i.e. ZS6BKW's need a tuner at the rig to get all the target bands)

Dipole...

(wherever you can put it up)

what kind of wire?

Copper, of course, or copper clad (not plated.)

Stranded “Flex weave”

What not to use:

- ___stainless steel for radiating element (i.e. whip)
- ___stainless steel for an inductor
- ___chrome plated telescoping elements / tips

Stainless steel used for a hairpin match on a Yagi
(used for only 2 weeks)

Tester said, "The antenna was like a piece of wood."

The black discoloring is from heat – lots of loss

A coil made of copper wire has a Q of >600

Same coil of stainless steel lowers the Q to <30



Is there stainless steel in your antenna?

How much could we lose with a simple stainless whip?



2 Meter test antenna

Mobile mag mount with a $5/8 \lambda$ stainless whip (generic pic)

- __Braid is tinned copper (just large enough to slide over the whip)
- __Signal source is Elecraft XG-3 at 144.2MHz (vertically polarized)
- __Test distance is 3λ (out of the near field)
- __Receiver Rigol Spectrum Analyzer (using max hold)

Test 1 stainless steel whip as is & then full length "braid-over"

- __Stainless -49.25dBm
- __full braid-over -47.45dBm **+1.8dB 100% braid**

Test 2 stainless steel whip as is & then bottom 1/2 "braid-over"

- __Stainless -49.29dBm
- __1/2 braid-over -47.85dBm **+1.44dB 50% braid**

Test 3 stainless steel whip as is & then bottom 1/3 "braid-over"

- __Stainless -49.24dBm
- __1/3 braid-over -48.51dBm **+0.73dB 33% braid**

Perhaps the decision is the trade-off between:

- __a) a flexible antenna that has almost 2dB loss ($\approx 40\%$ of your tx power and also 2dB* on receiving); or,
- __b) an efficient antenna that emits and receives your best signals, but is not as flexible.

* re: 2dB – page 2



Example path

Let's assign that it takes 20dB of path energy to communicate from A to B.



If antenna A has 10dB and antenna B has 10dB, the path is completed.



If antenna A has 8dB and antenna B has 10dB, the path *is not* completed.



If antenna A has 8dB and antenna B has 12dB, the path *is* completed.



How sensitive is a typical receiver these days?

A fraction of a microvolt signal; therefore, it doesn't take much signal for you to be heard.

The catch is you must get "something to Point B."

Example path

Let's assign that it takes 20dB of path energy to communicate from A to B.



If antenna A has 10dB and antenna B has 10dB, the path is completed.



If antenna A has 8dB and antenna B has 10dB, the path *is not* completed.



If antenna A has 8dB and antenna B has 12dB, the path *is* completed.



This chart does **not** apply when.....see page 4

2dB makes the difference

...you are:

Portable, SOTA, FD, back packing = temporary/very temporary station set-up

___and___ running low power/QRP (5 watts or less)

___and___ limited resources, including people and available support structures

___and___ time of day is probably daylight (implies 20 mtrs on up)

___and___ weather can be a controlling issue

___and___ terrain → antenna pattern might be unknown

___and___ only so much available time for set-up, operating and take-down

All the above means your installation must be optimized for maximum TX signal

__Time alone limits the station component that is the most important: your antenna.

__Regardless of your antenna, running very low power reduces the potential for making contacts.

___Therefore, other stations are the key to making any contacts –

the other stations will be making up the difference in the required signal path;

but, your signal must get to Point B and be at least above the noise.

___ With almost any antenna, we can hear stations that are very strong

___ signals might be 20 over 9, but that is not the issue

___ the key → is our signal above the noise at Point B?

___ if our signal is only at the noise threshold, how much stronger do we need to be to be heard?

___ 2dB, sometimes less

After several contests and several World Records, Team Vertical arrived at a consensus:



if we can improve an antenna by 2dB, it will bring in another layer of stations for us to work on that band.

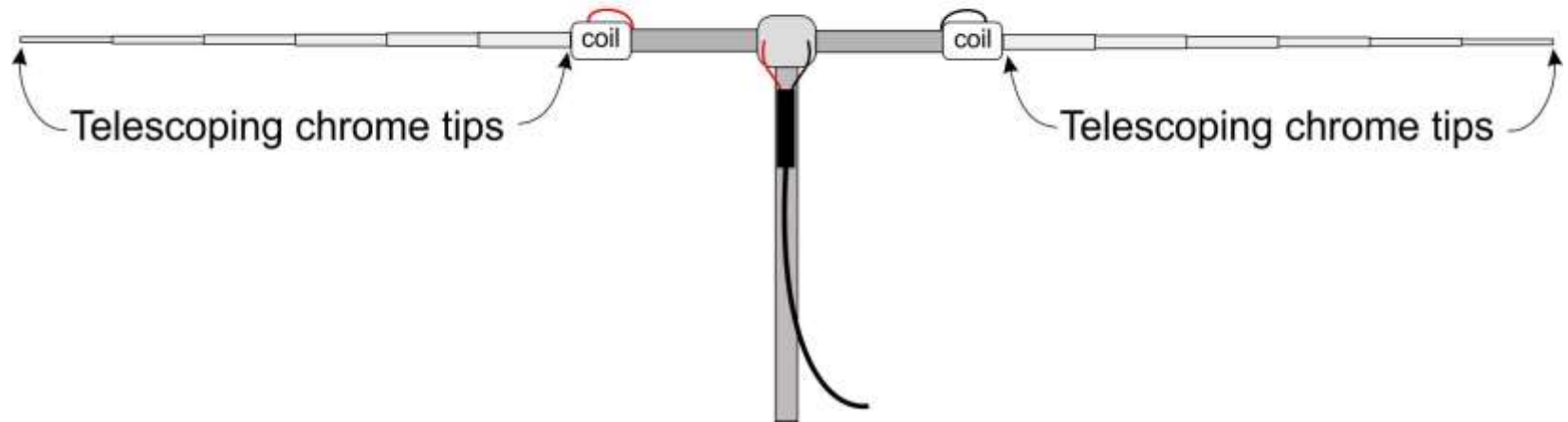


The lesson is simple: *it is not if you can hear signals, it's if they can hear you.*

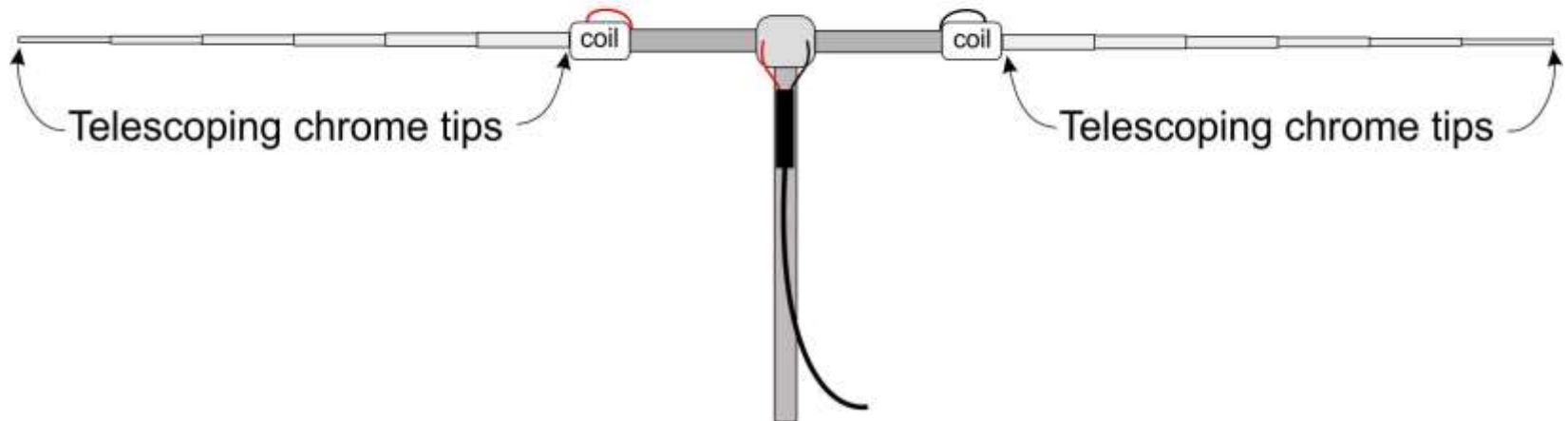
Every dB counts – don't lose any!

Besides the 2 mtr stainless whip, we also test other antennas.....

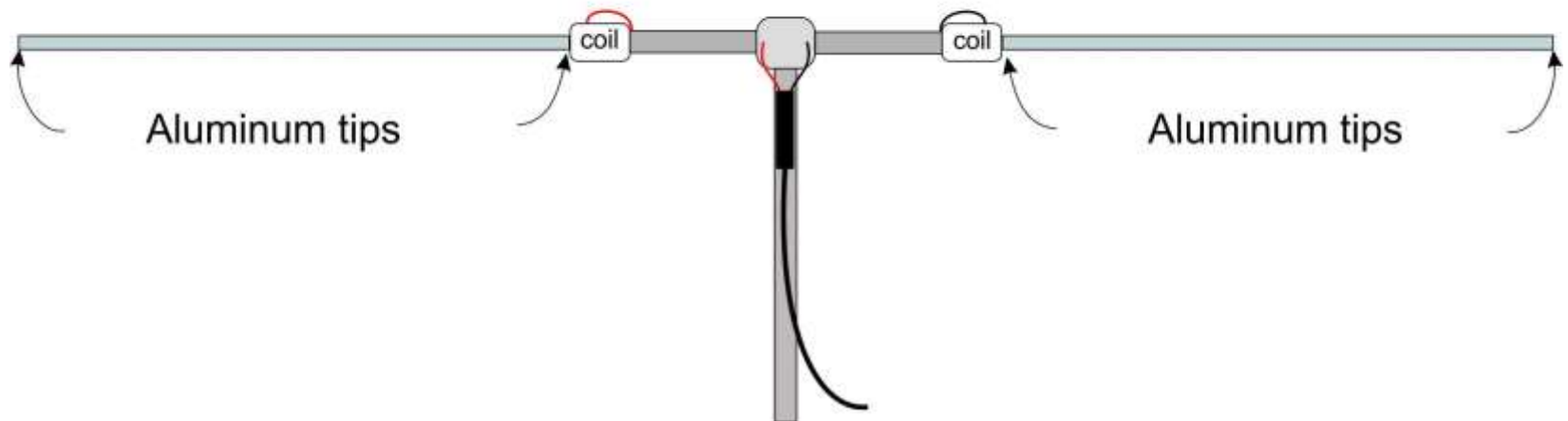
Portable antenna set as a 15 mtr dipole



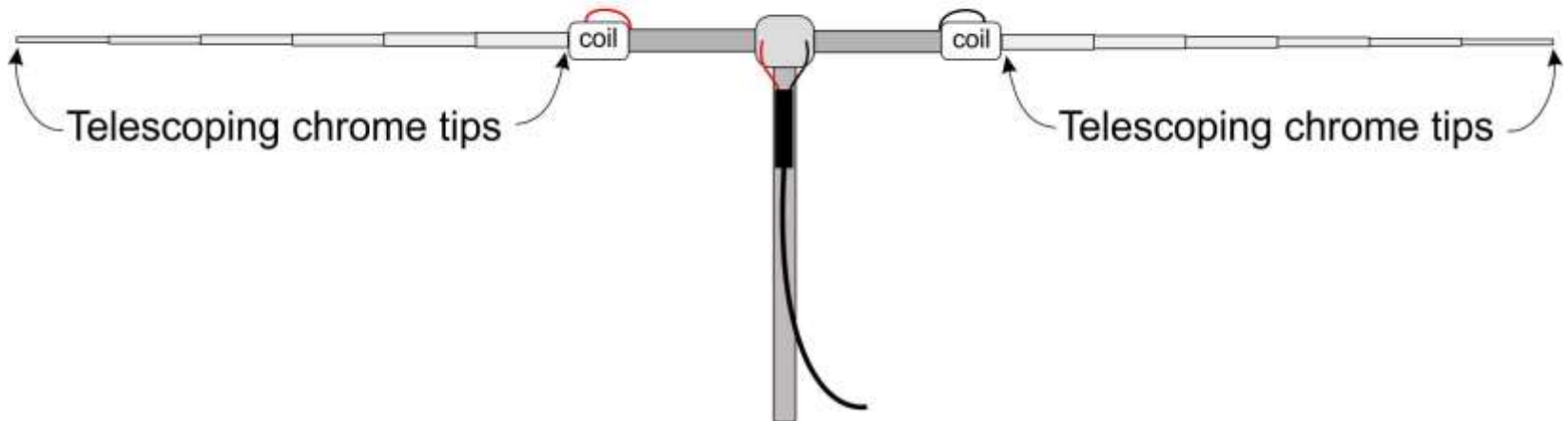
Portable antenna set as a 15 mtr dipole



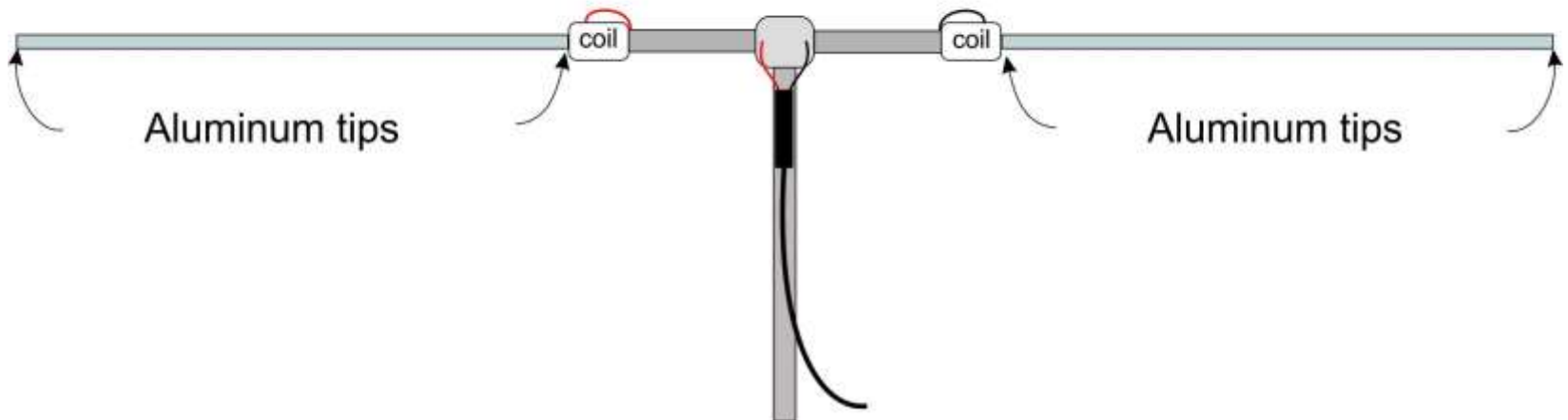
Portable antenna set as a 15 mtr dipole



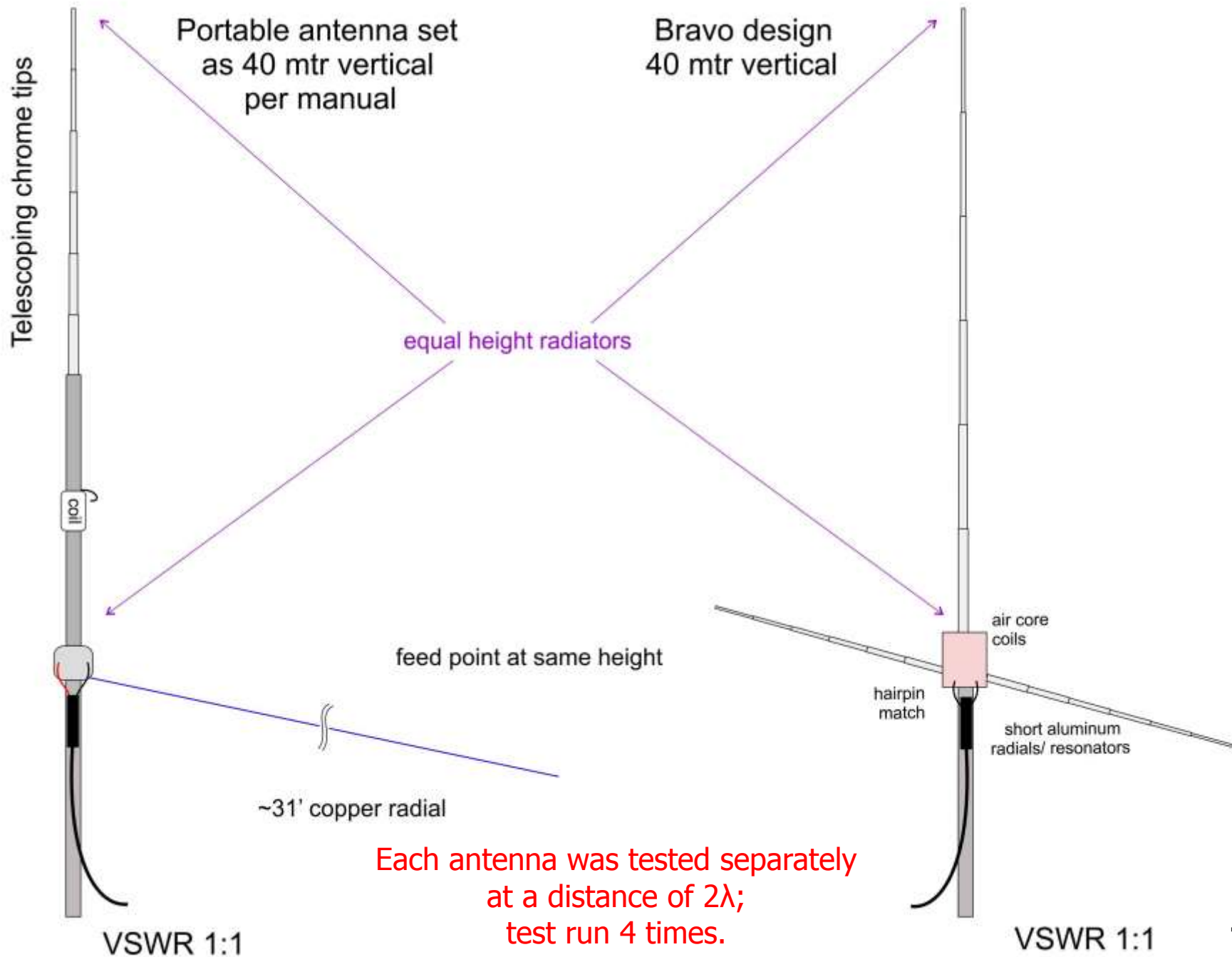
Portable antenna set as a 15 mtr dipole

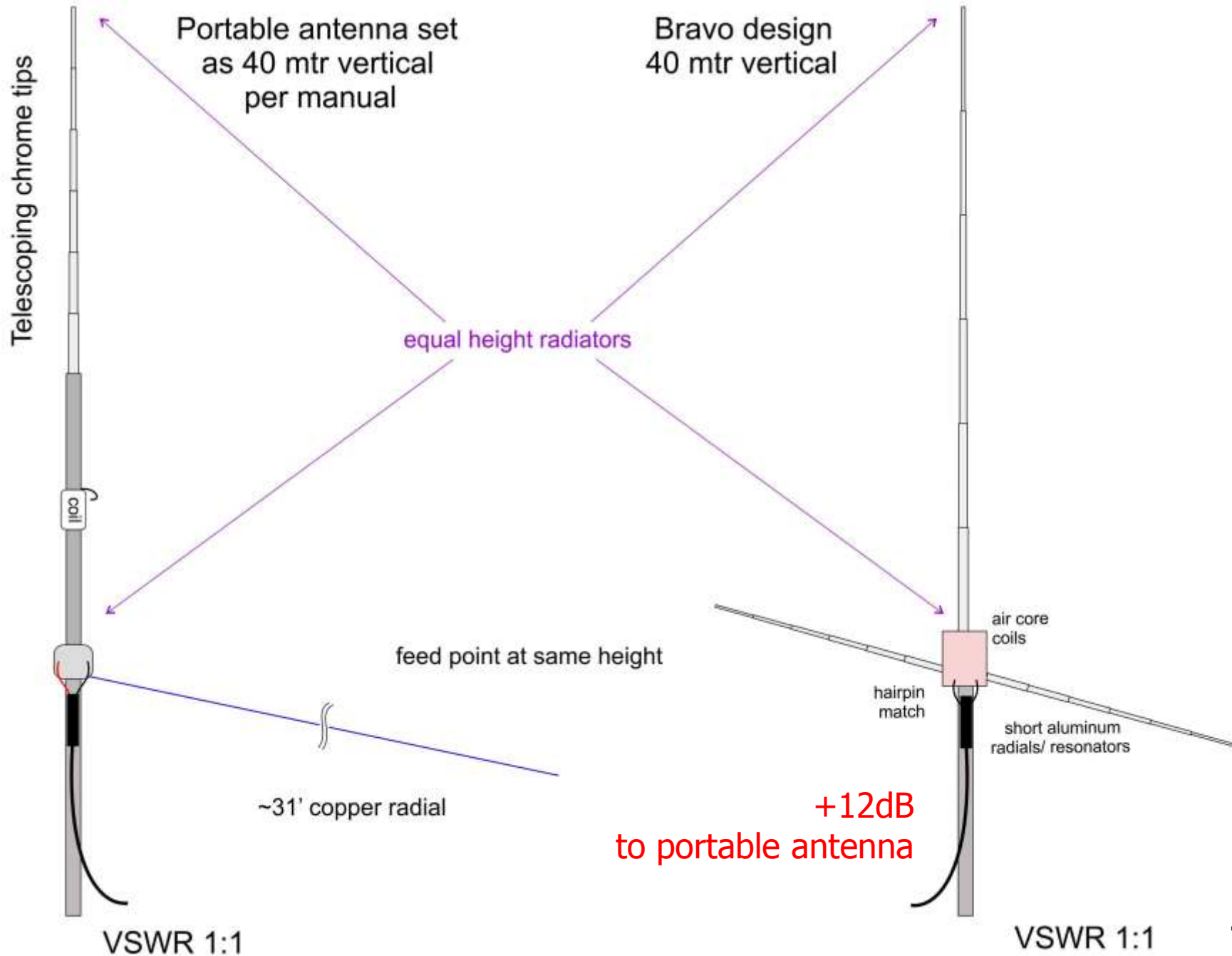


Portable antenna set as a 15 mtr dipole



+3dB to portable w/chrome tips





If you want to get on HF and work folks, sometimes long distances,
but you have limited space and restrictions,

there are some antennas you can make.

You probably will be running low power (200 watts or less)
and my suggestion is **not** to run QRP (5 watts).

General rules:

the lower power you run, the more important the antenna;

and,

your antenna is directly related to your enjoyment of radio.

“Life’s too short for QRP”

Bruce, N6TU (late ‘70’s)

The most restricted HOA I've ever worked with
and
we got him on the air 40 through 10 mtrs with a KW.

Two of the guy lines
on his wx station tripod
are a 40 mtr dipole
(inverted V)



Then we used an old trapped, triband dipole and mounted it
so that it wasn't visible as he walked down the street.



The concrete blocks sit in
welded aluminum trays.

The tips were adjusted, along with a little on trap spacing until
it had a reasonable match. He runs an ICOM transceiver and
KW solid state amplifier (40-10).

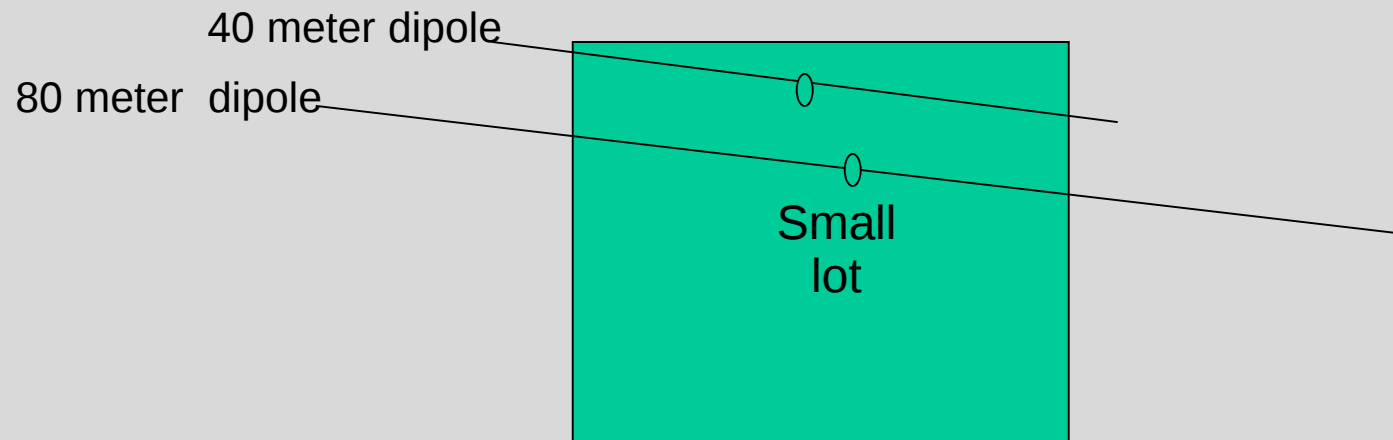
Optional listening on 40 is a small loop, about 5' in diameter.

Important to notice the antenna is outside, barely, but outside.



Knowing that a full-size dipole is very effective, but too long and won't fit in the available space, maybe we can go up instead of horizontally for smaller locations.

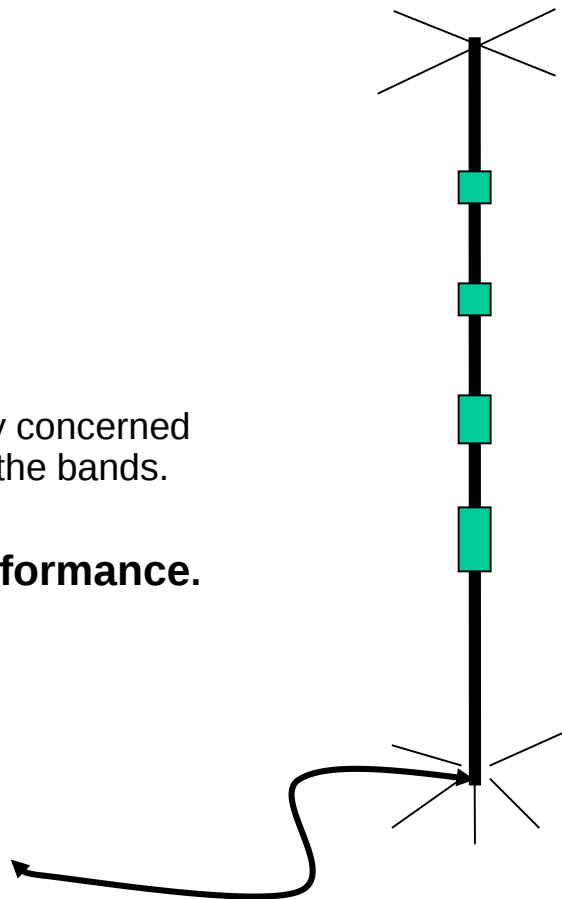
(Yes, the dipole ends can be bent, so this can be tried, too.)



“Going up” implies a vertical for our band of choice, or perhaps some method of the antenna “working” on several bands.

Trapped verticals appear mostly concerned about having a low VSWR on the bands.

My primary concern is performance.



A new look at verticals

2014 began empirical testing using drones



Discoveries to date about vertical antennas

1. The ground is not your friend - keep the vertical and horizontal components off the ground;
2. Linear loaded verticals are highly efficient;
3. 1/4 wave ground radials are actually ~25-30% too long, which places the maximum current in the ground, rather than in the vertical;
4. Verticals using 1/4-wave ground radials usually get shortened, ensuring that the maximum current is in the ground (shorten the radials, instead);
5. A “classic vertical” will be ~7dB down from a vertical with elevated, tubing radials;
6. The take-off angles for vertical antennas have been measured to be substantially lower than the computer model indicates;
7. Verticals by salt water have energy down to the water ($<1^\circ$);
8. Verticals adjacent to sloping ground have energy that follows the slope and measurements on sloping ground of $8-12^\circ$ show that the vertical has energy at and below the horizon;
9. Measurements comparing full size (asymmetric) vertical dipoles to full size horizontal dipoles shows them to be within the margin of error in field strength, meaning that the often-quoted 6dB of ground reflection gain for the horizontal is not seen;

Discoveries to date about vertical antennas

10. The most efficient vertical is a full-size vertical dipole (90 ohms);
11. The most efficient compressed size vertical is the ZR design, because it is an electrically full size, half-wave element;
12. A full size Sigma is almost identical to the ZR, but shares the same awkward feed point in the middle of the vertical element;
13. Asymmetric vertical dipoles are user friendly with the feed point at (or close) to the bottom;
14. Asymmetric vertical dipoles can be built as rotatable beams (no tower);
- 15 A 2el broadside vertical array has reasonable (~4dB) gain to a single and a narrow beam pattern, making it quiet on receive and broad-banded;
16. Asymmetric vertical dipoles, as well as other verticals that are asymmetric, have a current imbalance that causes balun heating and a loss of energy;
17. The 2017 Gen-7 vertical design is a balanced current, physically asymmetric vertical dipole that does not heat up the balun;
18. VOR is as effective as (2) full length Gull-Wing radials (modeled within 0.1dB) and takes up less⁸² space.
19. Verticals do not necessarily need to look like an antenna.

Discoveries to date about vertical antennas

**** main items ****

5. A “classic vertical” will be ~7dB down from a vertical with elevated, tubing radials;
6. The take-off angles for verticals have been measured to be substantially lower than the computer model (i.e. NEC-2, AO, etc.) indicates;
7. Verticals by salt water have energy down to the water;
8. Verticals adjacent to sloping ground have energy that follows the slope and measurements on sloping ground of 8-12° show that the vertical has energy at and below the horizon;
9. Measurements comparing full size (asymmetric) vertical dipoles to full size horizontal dipoles shows them to be within the margin of error in field strength, meaning that the often-quoted 6dB of ground reflection gain for the horizontal is not seen;
18. VOR is as effective as (2) full length Gull Wing / straight radials (within 0.1dB) and takes up less space.
19. Verticals do not necessarily need to look like an antenna.

Additional detailed research by N6LF, see also [QEX](#)

What can you make that will work well?

Specifically – how to make an efficient vertical without buried radials

An initial assessment to make might be to:

___think about the possibilities of your property and,

___decide on one, maybe two bands

_____recognize the limitations.

A vertical does need "something" for a current return.

Given limited space, most likely not enough room for a well-designed ground radial system, such as described by N6LF's work.

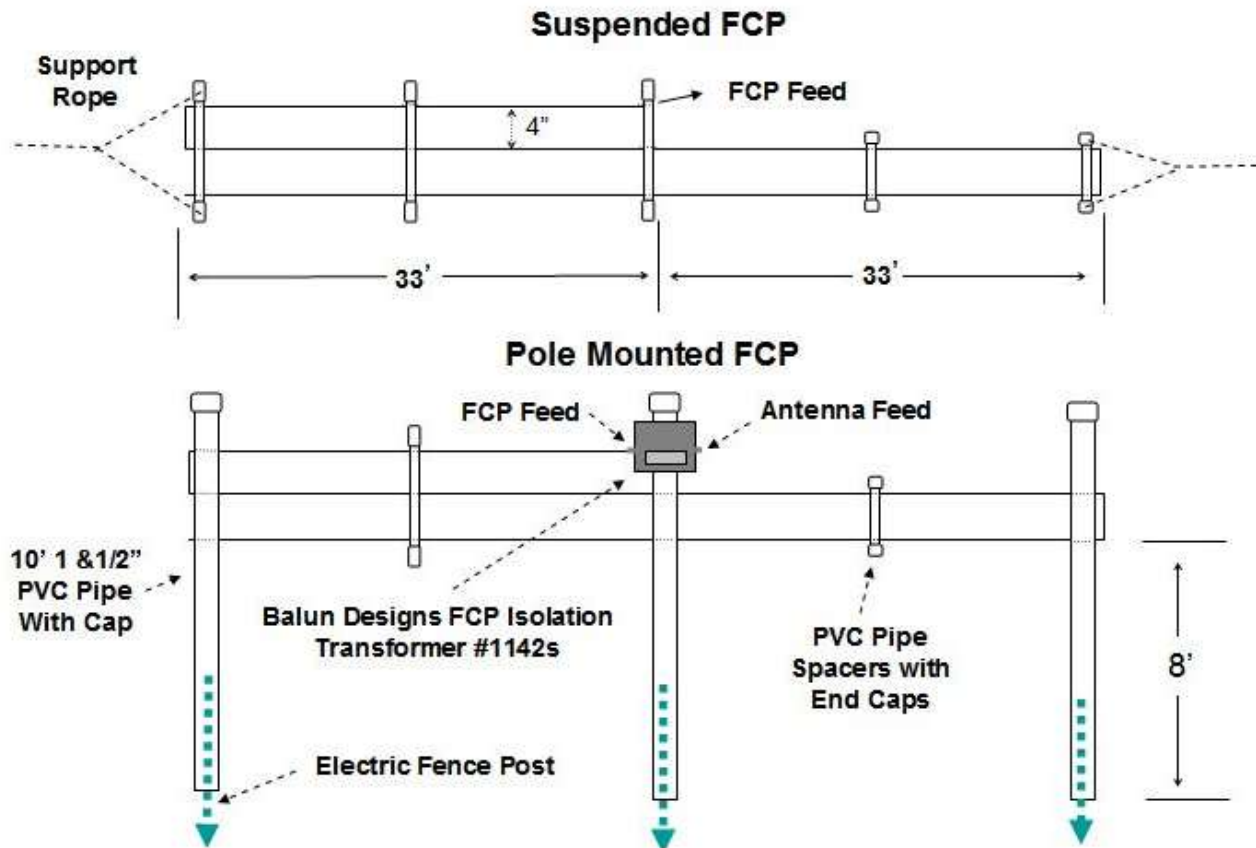
Interested in the LOW BANDS?

Limited space, high efficiency
“radials”, “counterpoise”, “current return” for verticals
on 160, 80 and 40.

One design that many use is the FCP by K2AV...

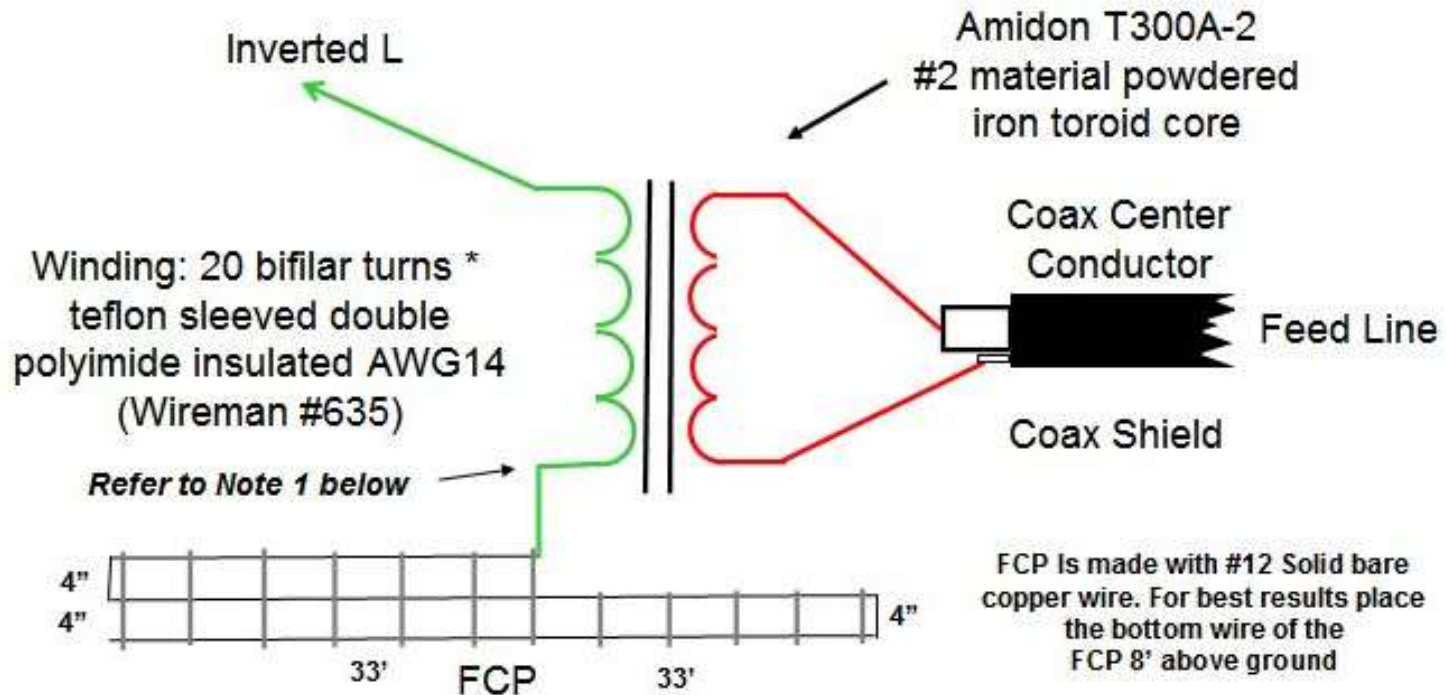
Guy Olinger, K2AV, has created an alternative - the folded counterpoise (FCP). An FCP is not magic. It has no gain. An FCP improves an antenna system by replacing more loss with less loss. Some have been able to erect better wires in the air because the small size of the FCP allowed better placement of the antenna. Such a multiple factor improvement project sometimes produces startling changes. Of course, the biggest improvement is that the FCP made possible the first 160 antenna on my property. Detailed construction information for an FCP:

K2AV FCP Details & Support Options



It is fed by a special isolation transformer...

K2AV 33 x 33 160m Folded Counterpoise (FCP) and Isolation Transformer



* Bifilar turns: Instead of the two windings kept separate, one wire on one side of the toroid and one wire on the other side, the two wires are kept in a pair like a length of zip cord. The PAIR of wires is wound around the toroid twenty times. For this application 15 feet of wire and teflon sleeve, cut in half, provides the required PAIR length of 7.5 feet.

Approximate space required for a vertical using the FCP:

Horizontal is 66' for 160 + end supports

34' for 80 + end supports

18' for 40 + end supports

The space for the FCP was still too large for many installations;
we continued developing a smaller footprint, high efficiency current return.

The VOR - Vertical, Open Ring

__Gull Wing radials are excellent. Require a lot of horizontal space and supports at each end.
Adapted from a new I.E.E.E. article (circa 1997) about AM broadcast stations using elevated wire to replace aging, buried radials. Commercial empirical testing showed that (4) elevated wires equaled 120 buried ground radials.

__ZR's are also excellent. Mechanically difficult and best suited for 40m on up.



__Sigma style (simplified ZR design). Feed point is an issue.

Sigma vertical like
a large letter "I"



__Bravo design (simplified Sigma). Mechanically and electrically superior.

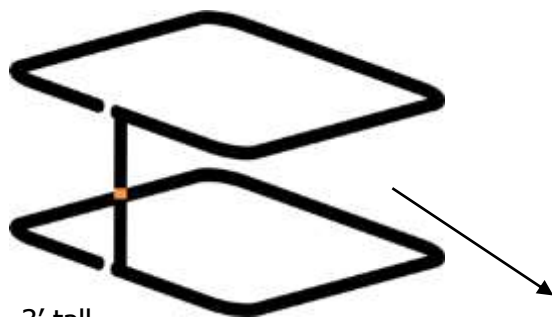
Bravo vertical



All required too much space.
None of the above were the answer, nor was the K2AV FCP.

VOR development went back to the original ZR from 1995-96

20 mtr proto-type



3' tall

full length 20 mtr dipole =
vertical section + 2x ring length

ZR-3

20-15-10 mtrs



6' tall

one feed line

no loading

no traps

2017-18

Open Ring on a 40 vertical



The VOR is basically a ZR minus the upper ring.

This 40 mtr ring is about 7' per side and is elevated to minimize interaction with the ground (i.e. 4' on 40 meters).

Comparative computer models are as follows

(80mtr vertical system over salt water; however, efficiency is the same for other ground types)

		Efficiency		
Full size vertical	#14 Gull Wing radials @8'	95.2%	-0.21dB loss	4.68dBi @8°, 4.55dBi@5°
Full size vertical	FCP (8' away, ~36' long)	86.1%	-0.65dB loss	4.08dBi @8°, 3.95dBi@5°
Full size vertical	VOR-4 sides (#14 wire) @7'	94.0%	-0.27dB loss	4.47dBi @8°, 4.34dBi@5°
Full size vertical	VOR-3 sides (#14 wire) @7'	94.5%	-0.25dB loss	4.50dBi @8°, 4.37dBi@5°
Full size vertical	VOR-4 sides (.3" tubing) @7'	97.5%	-0.11dB loss	4.63dBi @8°, 4.50dBi@5°

**The VOR model looks good on efficiency
(even though half of it is #14 wire),**

but

one good test is worth a thousand theories, right??

Let's start with one and go from there.....

First test is to compare (2), full length, tuned, straight, elevated radials ("FLR") to the VOR.

Test conditions:

- a) Same length vertical radiator tuned to 21.100 MHz with FLR and VOR, radials & open ring are #14 solid copper
- b) Same feed point, height above ground, balun and feed line
- c) XG-3 signal source, 100' distance, varying height and output level, running max hold

Results:

Test 1	VOR = -64.90 dBm	FLR = -65.67 dBm	VOR is	+0.77	lowest	T/O	angle
Test 2	VOR = -57.72 dBm	FLR = -58.38 dBm		+0.66	"	"	"
Test 3	VOR = -74.38 dBm	FLR = -74.42 dBm		+0.04	max	T/O	angle
Test 4	VOR = -74.60 dBm	FLR = -74.55 dBm		-0.05	"	"	"
Test 5	VOR = -61.89 dBm	FLR = -61.73 dBm		-0.16	"	"	"

Overall, the VOR is equal to a pair of full length, tuned, elevated wire radials;
the computer model is close to the test data.

...next...

Built a 2 element 20 meter (driver/reflector) VOR and ran many tests over the air using the RBN, comparing it to a 5-band (trapless) Yagi at 45'.



The 2 element VOR was sometimes equal to the Yagi, occasionally better, most often a little behind ($\sim 2\text{dB}$); however, anyone who has used the RBN knows it is very difficult to make exact comparisons, even with the same antenna.

The issue is not one being horizontal and the other vertically polarized, it is antenna efficiency (gain/loss) and take-off angle to the target zone.

Obvious trade-offs:
45' crank-up tower, plus medium-size Yagi, plus rotator and no HOA's
vs
two verticals on the ground that can be easily moved and taken apart.



Let's compare verticals with verticals:
empirical testing of the VOR to the "classic" vertical with a ground radial system.

Initial procedure for testing at 21.020 MHz:

- a) Prepare (2) vertical bases with base sections that are equal in length (14" tall)
- b) Tune a pair of full length, elevated ($\sim 3'$) radials (#14 solid copper)
- c) Connect a 1:1 ferrite core balun and coax feed line to the vertical feed point
- d) Add a telescoping tubing vertical and tune to the desired frequency = "Vt"
- e) Cut a VOR ring wire (#14 solid copper) that is $\sim 10\%$ longer than one of the radials in b)
- f) Install the ring wire, add Vt and tune the ring wire to resonance. The VOR is now tuned (VSWR $< 1.2:1$).
- g) Cut (4) full length $\frac{1}{4}\lambda$ radials using the formula $246/f(\text{MHz}) = \text{"FLR"}$
- h) Attach (4) FLR to the vertical base and lay out the radials on the ground (secured with rocks)
- i) Move the 1:1 ferrite core balun, coax feed line and Vt (the tuned vertical) from the VOR to the vertical base
- j) Set XG-3 signal source at 80' distant and elevated 11° on non-conductive fiberglass/PVC mast



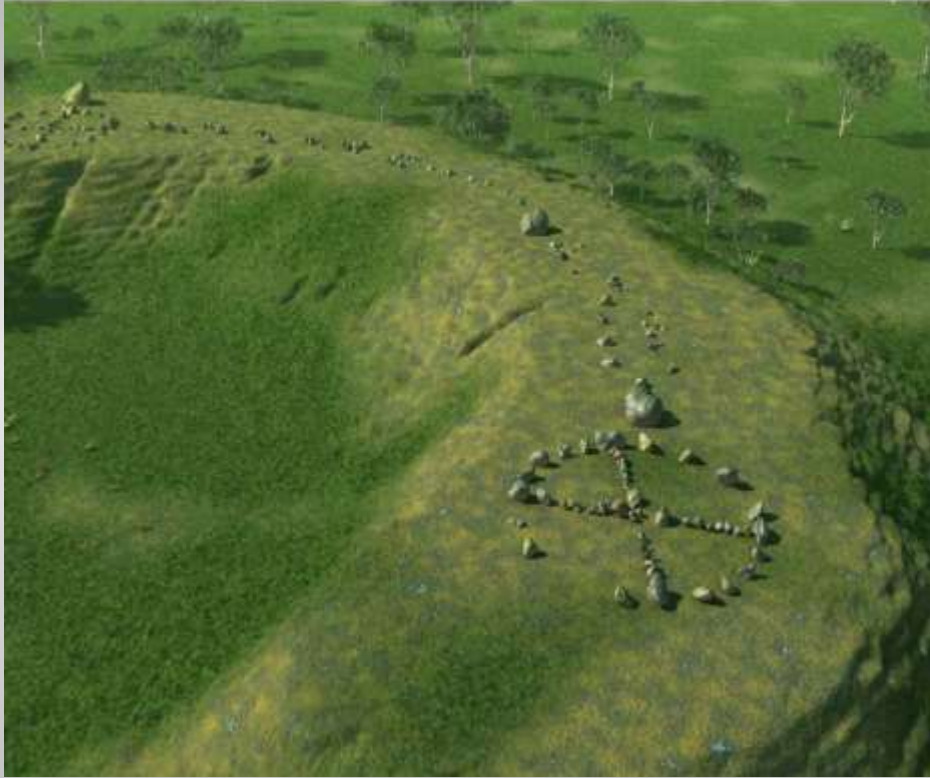
welded aluminum hub = vertical base

Note: elapsed time for preparation and testing is four days.



Starting with (4) full length
and
eventually get to (16) cut length ground radials





Australian Standing Stones
(aka "Stonehenge")



Australian Standing Stones
(aka "Stonehenge")



16 ground radials held with rocks

Our initial test of (4) full length ground radials



welded aluminum hub = vertical base



How did this tune up?



welded aluminum hub = vertical base



5-gal plastic bucket
w/concrete/PVC

a) From our prior empirical testing (i.e. WI6R), Team Vertical and data from N6LF's extensive work*, the resonance should be significantly lower in frequency...

...and...it was!

Vt (length) was set at 21.100 MHz and this test with (4) FLR was 19.500 MHz and about 1.1:1

b) Next is to add (4) more FLR, for a total of (8).

N6LF's data says it should move the resonant frequency UP.

* QEX Ground Systems Part 2, January-February 2009, Table 4



Vt with (4) FLR was at 19.500 MHz, much lower than the original 21.100 MHz.

Adding (4) more FLR for a total of (8) moved the frequency up to 20.450 MHz, as expected.

Measuring the signal strength (received at the vertical) from the XG-3 at 80°/11°

Tuned the verticals independently with (4) and (8) FLR:

vertical with (4) FLR was -72.75dBm

(8) FLR was -70.19dBm for an improvement of +2.56dB N6LF shows +2.26dB)

My ground is desert and N6LF is nice grass.

103

Rudy Severns, N6LF

Experimental Determination of Ground System Performance for HF Verticals Part 2

Excessive Loss in Sparse Radial Screens

QEX - January-February 2009, Table 4

Table 4

Results for 4, 8, 16 and 32 Radials, with Lengths of 33 Feet and 21 feet.

<i>Number</i>	<i>33-Foot Radials Feed Point Impedance (Ω)</i>	<i>21-Foot Radials Feed Point Impedance (Ω)</i>	<i>33-Foot Radials S21 Relative to Four 33-Foot Radials (dB)</i>	<i>21-Foot Radials S21 Relative to Four 33-Foot Radials (dB)</i>	<i>Delta Gain Change (dB)</i>
4	89.8	52.5	0	3.08	3.08
8	51.8	45.6	2.26	3.68	1.42
16	40.5	42.8	3.76	3.95	0.19
32	37.7	41.6	4.16	4.04	-0.12



Comparing the Vertical w/(8) FLR to the VOR over (8) FLR

Replacing the Vertical section with the VOR and Vt, sitting over the (8) FLR.

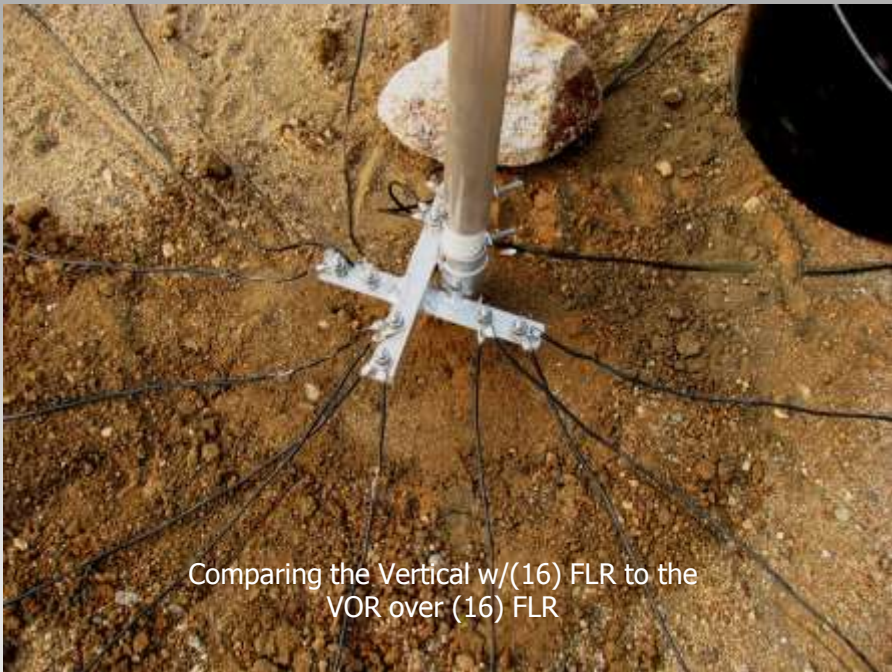
For this test, we add a non-resonant "candle" receive antenna that is way off to the side and shows its received signal strength on each vertical test for a reference (windy conditions move the XG-3, creating small changes).

The vertical with (8) FLR was -70.19 candle -80.71 = 10.52dBm

VOR over the (8) FLR was -69.85 candle -80.83 = 10.98dBm

VOR is 0.46dBm ahead, which might be due to the presence of the FLR on the desert sand and/or the VOR feed point being elevated 40"; or, *the (8) FLR are simply not adequate.*

Let's put all our rocks out...



Comparing the Vertical w/(16) FLR to the
VOR over (16) FLR

Adding another (8) FLR and using Vt, frequency moved up from 20.450 to 20.640 MHz.
Retuned the vertical with (16) FLR and tested it and the VOR over the (16) FLR:

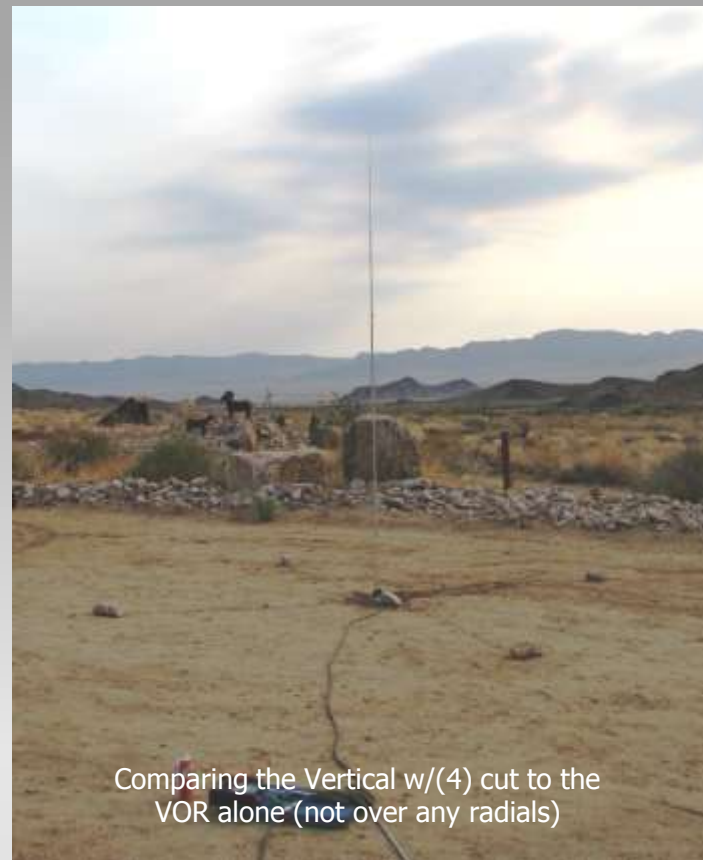
The vertical with (16) FLR was -70.60 candle -81.26 = 10.66dBm

VOR over the (16) FLR was -70.64 candle -81.32 = 10.68dBm

The vertical w/(16) FLR and the VOR over the (16) FLR are equal.

We know the FLR are too long, so cut them by the N6LF percentage of ~30%: 11' cut to 7'.

Cut and go back to (4)...



Vertical with (4) radials using -30% length. This moved the frequency up to almost V_t ; a good sign that max current is no longer in the ground and the VSWR increased slightly (also good).

Using a vertical track moving the XG-3 to measure the maximum signal from 3° - 12°

Vertical with (4) Cut radials = -73.62dBm

VOR alone, not over the (4) Cut = -71.87

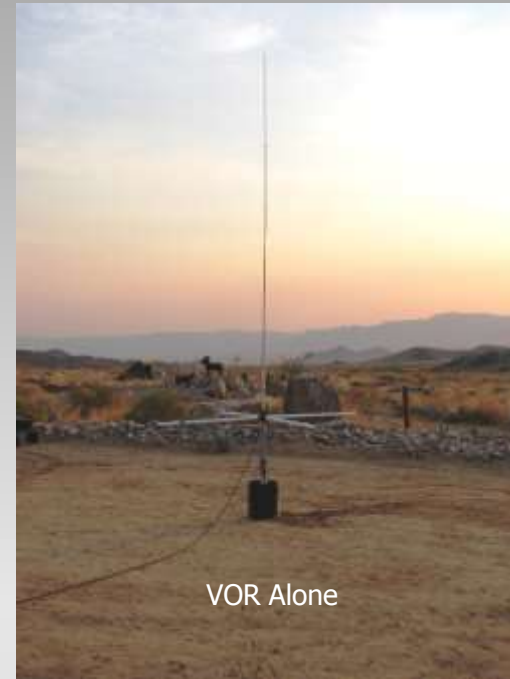
VOR is +1.84 dBm

Now to the final test using (16) Cut radials vs. the VOR alone.

Let's go for it...



=



Cut all the (16) radials ~30% and re-tuned the vertical, which was quite close to V_t . This indicates the maximum current is not in the ground and the VSWR climbed slightly (good).

Using a vertical track moving the XG-3 to measure maximum signal from 3°-12°, decreased XG-3 signal level.

Vertical with (16) Cut radials = -79.54dBm

VOR alone, not over any radials = -79.60

VOR over the (16) Cut radials = -79.43

VOR is -0.06 dBm

(16) Cut offers ~0.2dB improvement

The vertical w/(16) Cut/tuned radials and the VOR are equal.



Vertical w/(16) Cut
ground radials

=



VOR Alone

Adding another 16, for a total of 32 cut radials would not be a significant improvement over the VOR.

Possibly using (32) full-length radials would provide some improvement over the VOR.

On the high bands, (32) or even (16) radials might not be a major task; however, on the low bands, it certainly can be difficult, or impossible.

Table 4

Results for 4, 8, 16 and 32 Radials, with Lengths of 33 Feet and 21 feet.

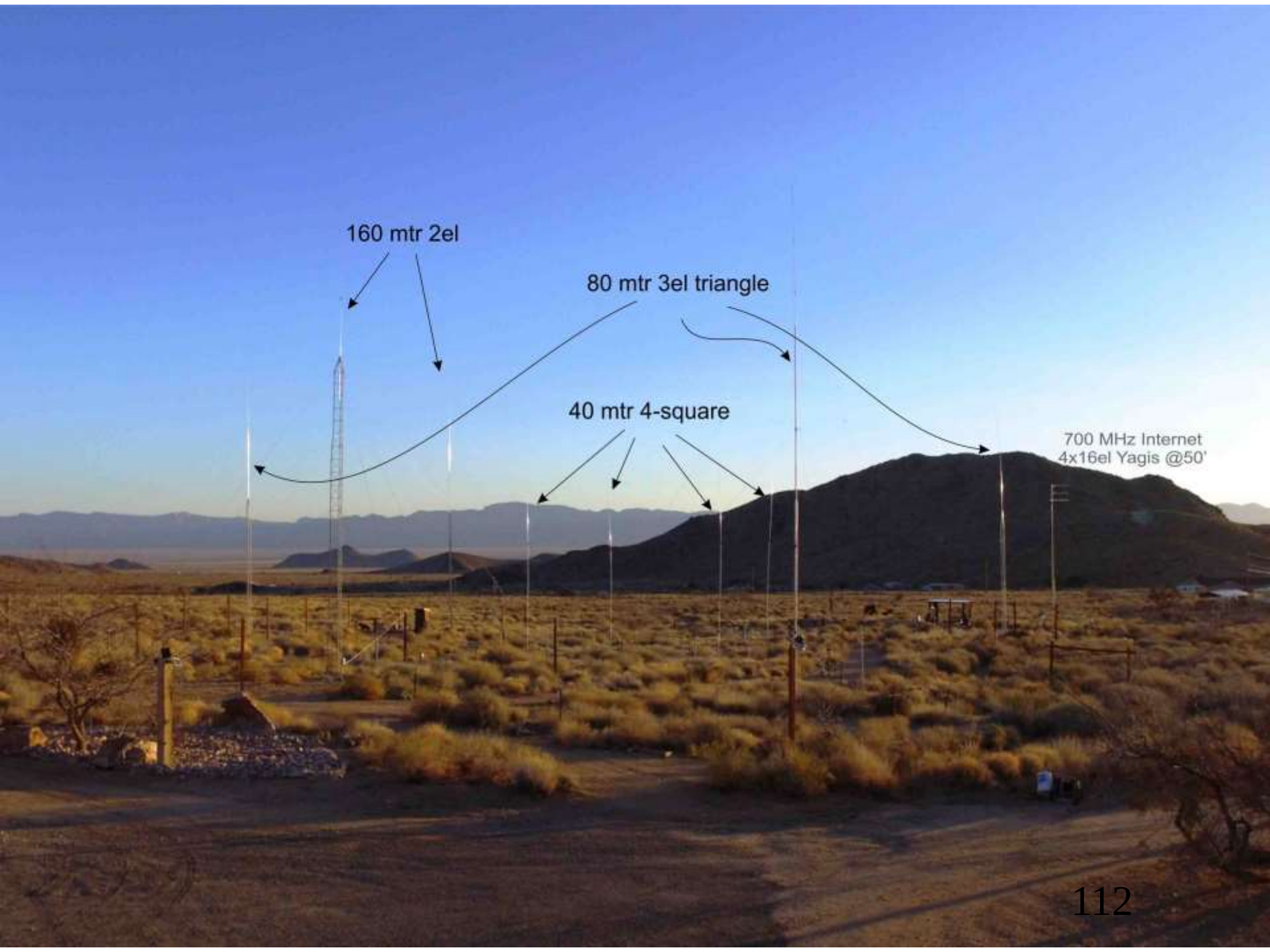
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16	40.5	42.8	3.76	3.95	0.19
32	37.7	41.6	4.16	4.04	-0.12

**Earlier in this presentation, there was a photo of our
verticals in NW Arizona.**

Here are some details →



4el on 40 (4-square)
3el 80 mtr triangle phased broadside
2el 160 phased end-fire & broadside
No ground radials – all use the VOR (vertical open ring)

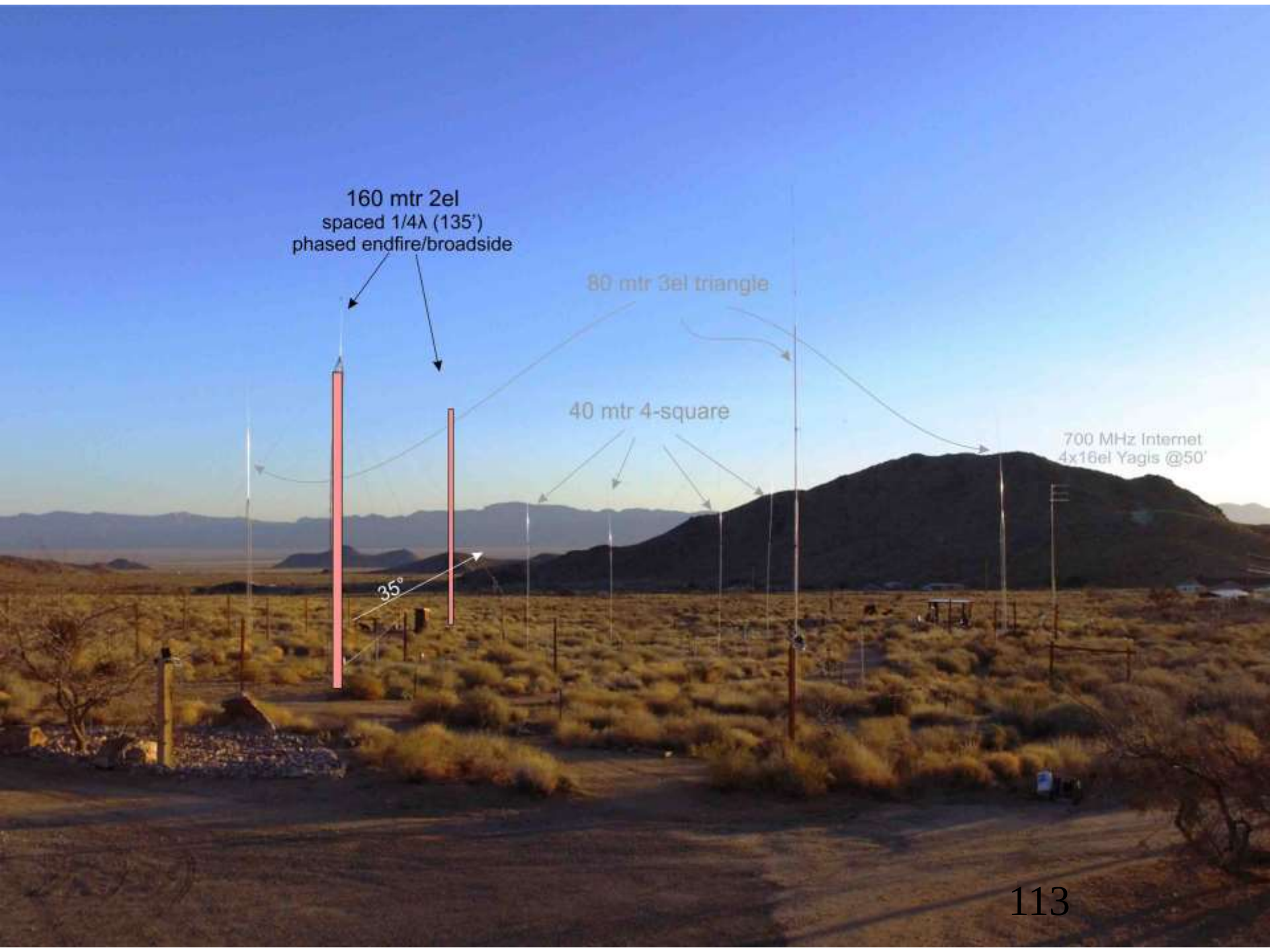


160 mtr 2el

80 mtr 3el triangle

40 mtr 4-square

700 MHz Internet
4x16el Yagis @50'



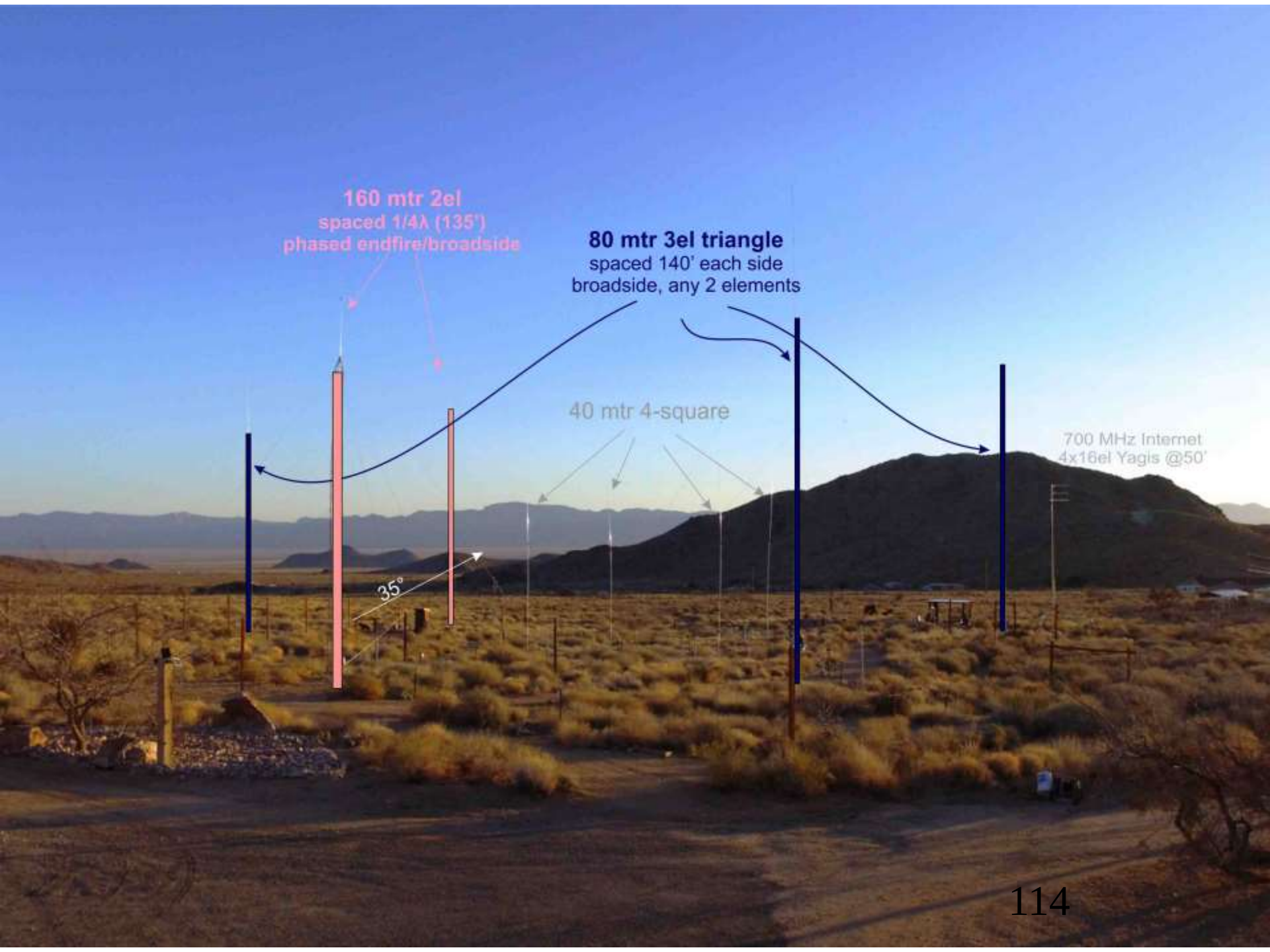
160 mtr 2el
spaced $1/4\lambda$ (135')
phased endfire/broadside

80 mtr 3el triangle

40 mtr 4-square

700 MHz Internet
4x16el Yagis @50'

35°



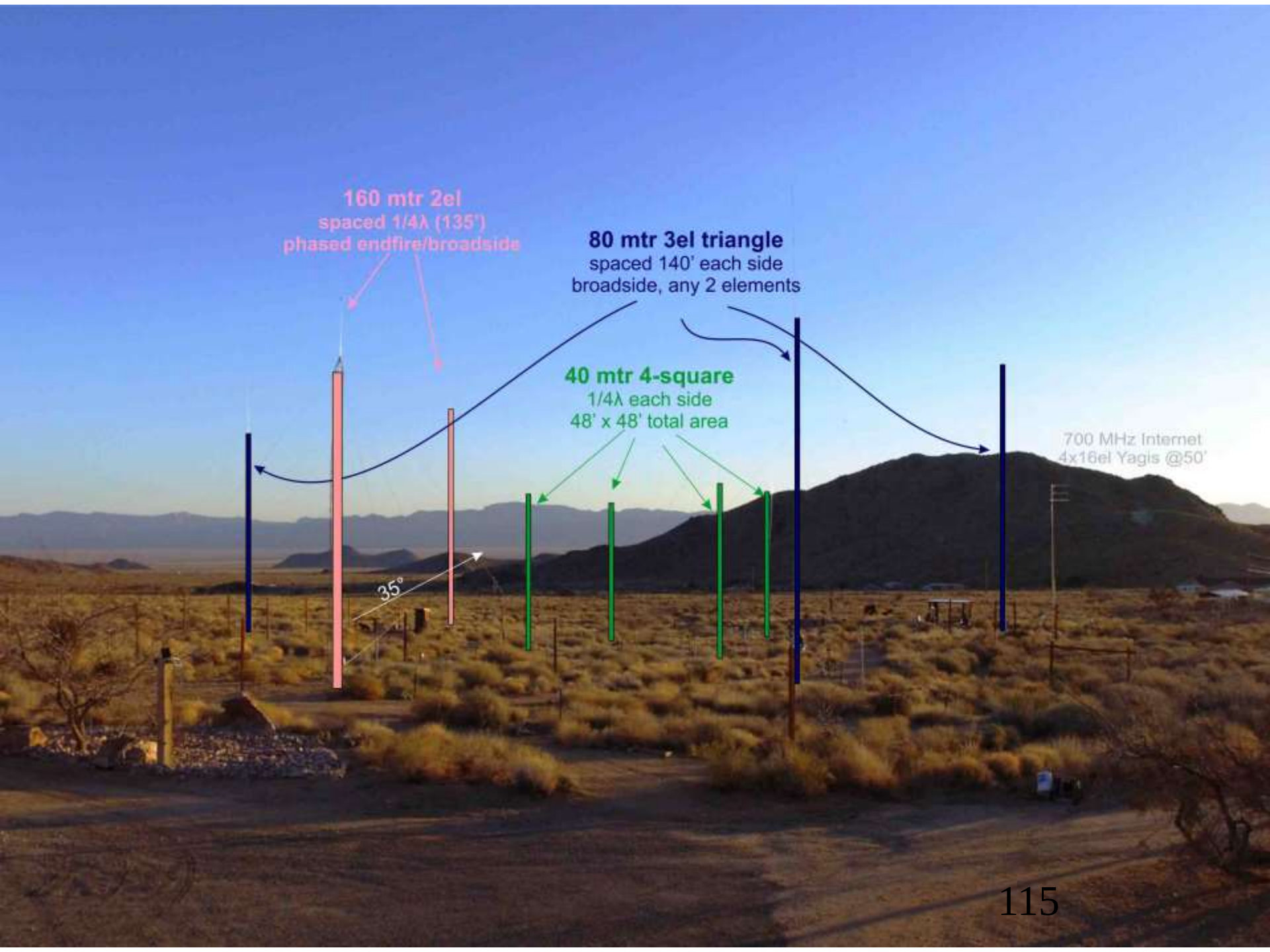
160 mtr 2el
spaced $1/4\lambda$ (135')
phased endfire/broadside

80 mtr 3el triangle
spaced 140' each side
broadside, any 2 elements

40 mtr 4-square

700 MHz Internet
4x16el Yagis @50'

35°



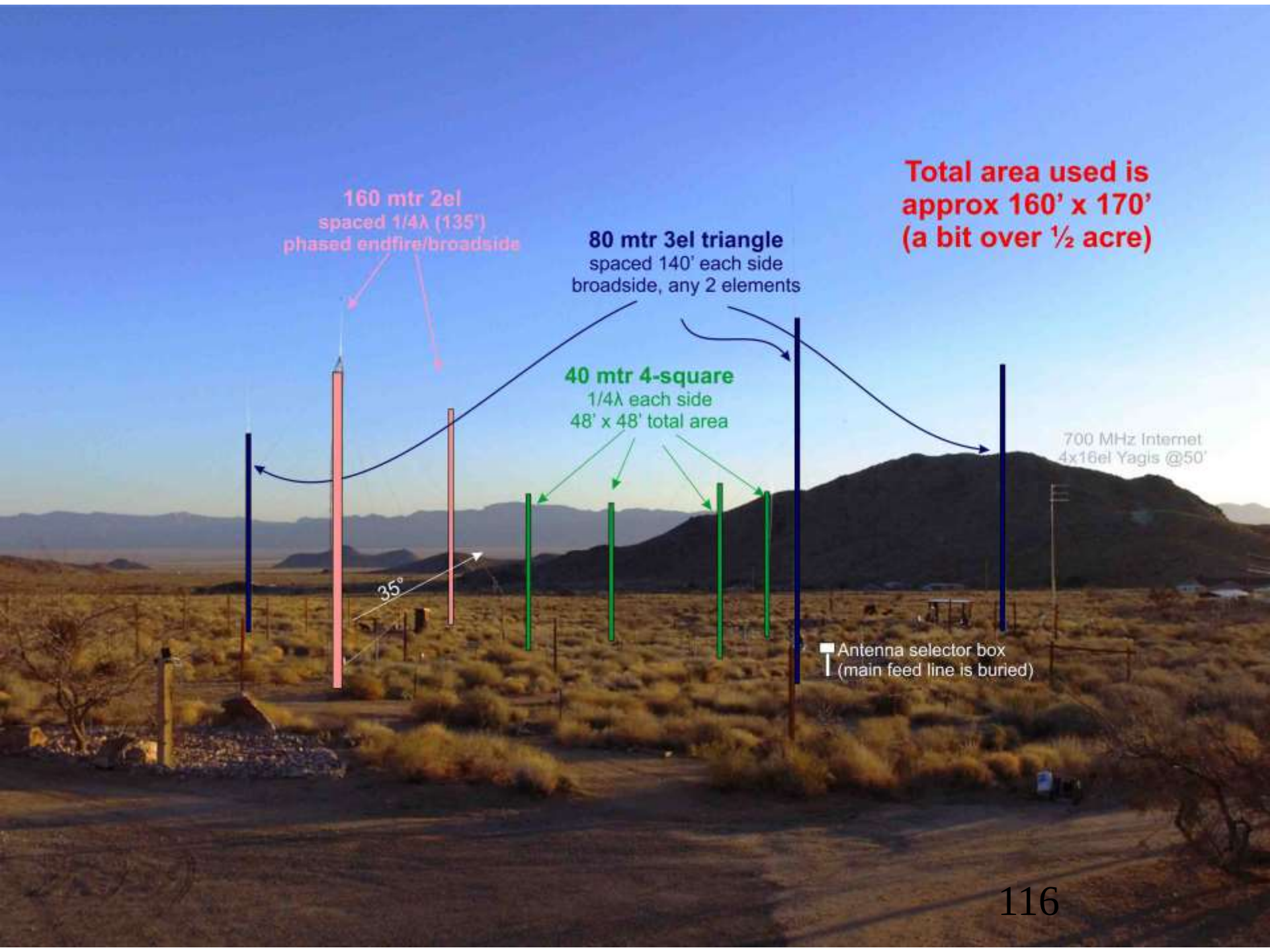
160 mtr 2el
spaced $1/4\lambda$ (135')
phased endfire/broadside

80 mtr 3el triangle
spaced 140' each side
broadside, any 2 elements

40 mtr 4-square
 $1/4\lambda$ each side
48' x 48' total area

700 MHz Internet
4x16el Yagis @50'

35°



160 mtr 2el
spaced $1/4\lambda$ (135')
phased endfire/broadside

80 mtr 3el triangle
spaced 140' each side
broadside, any 2 elements

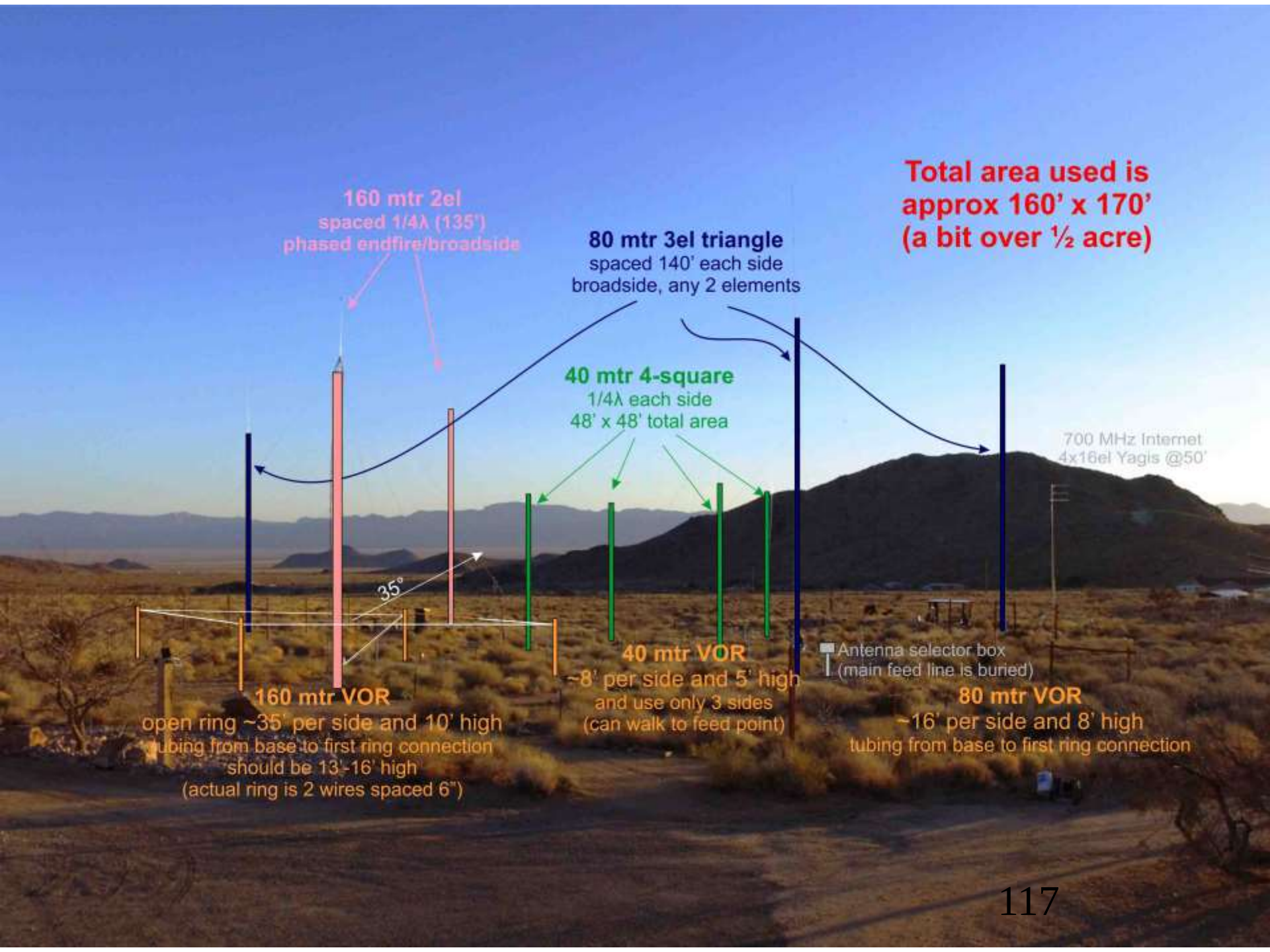
40 mtr 4-square
 $1/4\lambda$ each side
48' x 48' total area

Total area used is
approx 160' x 170'
(a bit over $\frac{1}{2}$ acre)

700 MHz Internet
4x16el Yagis @50'

Antenna selector box
(main feed line is buried)

35°



160 mtr 2el
spaced $1/4\lambda$ (135')
phased endfire/broadside

80 mtr 3el triangle
spaced 140' each side
broadside, any 2 elements

40 mtr 4-square
 $1/4\lambda$ each side
48' x 48' total area

Total area used is
approx 160' x 170'
(a bit over $\frac{1}{2}$ acre)

700 MHz Internet
4x16el Yagis @50'

35°

160 mtr VOR
open ring ~35' per side and 10' high
tubing from base to first ring connection
should be 13'-16' high
(actual ring is 2 wires spaced 6")

40 mtr VOR
~8' per side and 5' high
and use only 3 sides
(can walk to feed point)

Antenna selector box
(main feed line is buried)

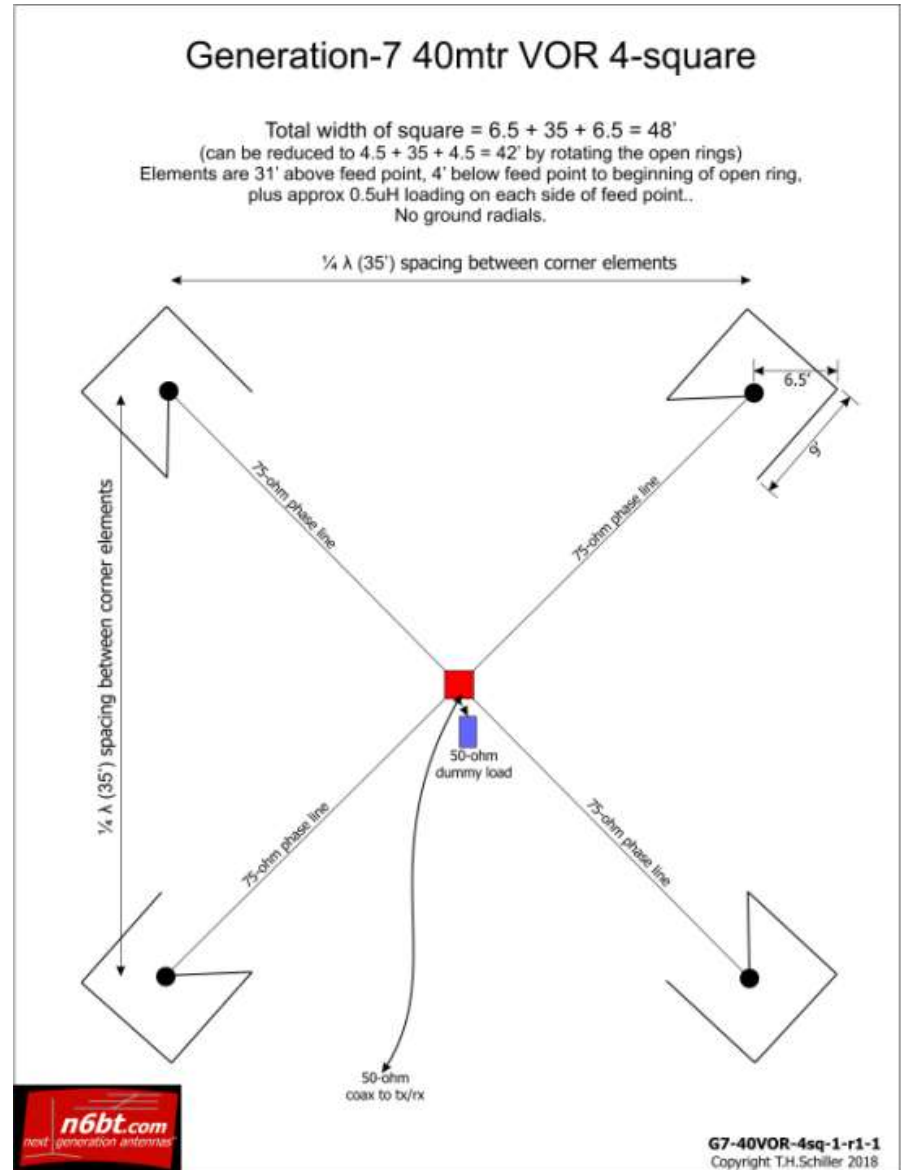
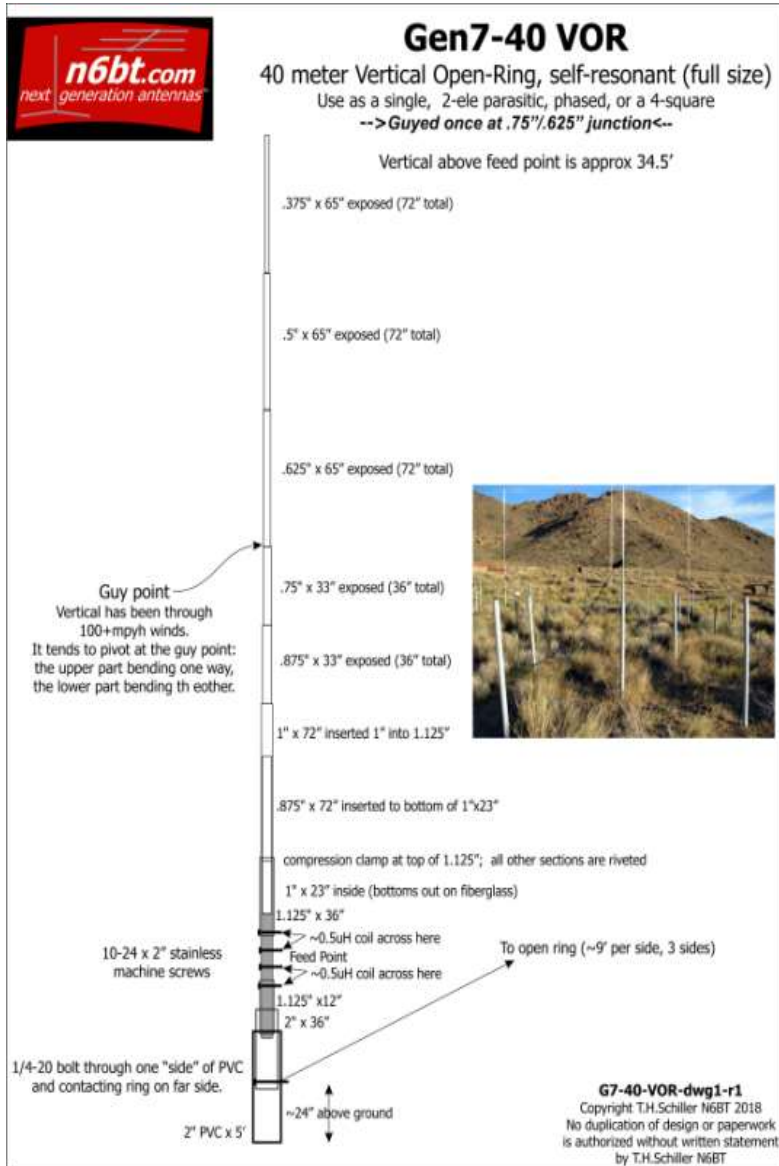
80 mtr VOR
~16' per side and 8' high
tubing from base to first ring connection

True
North

West Rim
G.C.

A lot of parallax in the photo;
however the aerial layout shows:
160 in pink
80 in dark blue
40 in green
Europe is generally straight ahead. North is noted.
The far mountain across the valley is the Western Rim of the Grand Canyon.

40 meter vertical (8'x8') and 4-square (48'x48')



75% full size 40-meter vertical using the VOR (3-sided)



VOR-40s

40 mtr monoband vertical dipole
vertical-open-ring design*

75% full size, no radials

vertical radiator is 24'

>95% efficient

open ring is all tube and 7'/side

integrated 2-core ferrite balun

enclosure is NEMA4, outdoor rated
gasket and snap-lock fasteners



VOR-40s-dwg1-r1

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* Patent Pending



120



G7-3B

20-17-15 Mtr Generation-7 Vertical

Vertical-Open-Ring balanced design
3-band relay-controlled, no radials
integrated ferrite balun

Low profile, small footprint, strong design.
Vertical above ring is ~10'9" of tapering tubing.
3-sided open ring is tubing, 34" per side.
Relay enclosure is NEMA-4 outdoor rated,
with latches and weather seal.
Internal ferrite core balun.
SO-239 coax connector.
3' base post (can be taller).
3-wire control cable (12VDC).
Full size 15, air-core inductors for 17 and 20.
20 mtrs is ~300kHz 2:1.



20-17-15 mtr

relay switched

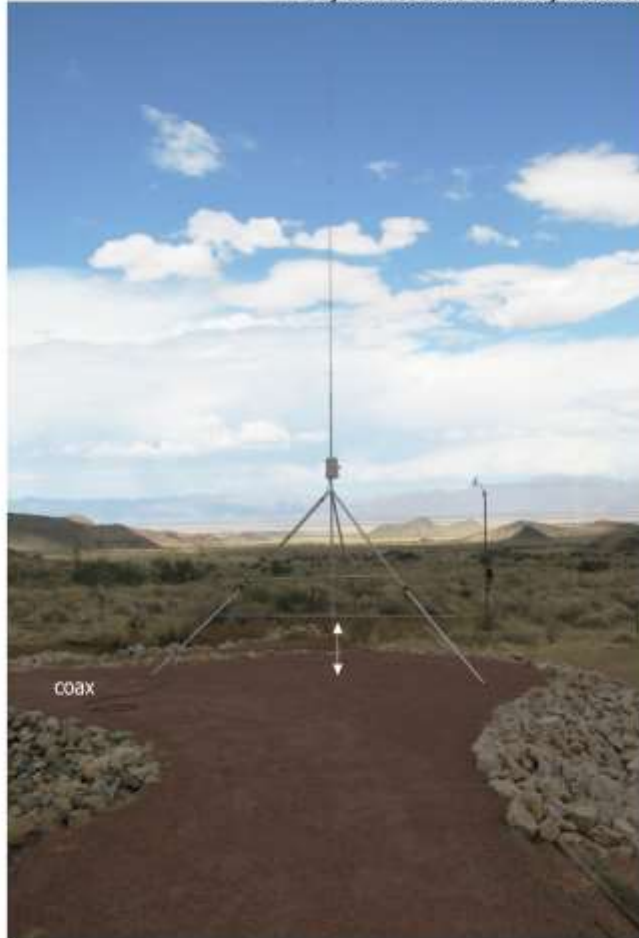
Full size for 15 mtrs;
loaded for 17 and 20 mtrs

G7-3B-dwg1-r1

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Gen7-40

40 meter vertical antenna
for permanent installations, DXpedition, portable
Use as a single vertical, in a 2-element parasitic,
or in phased arrays, such as a 4-square
-->Guy at least once for heavy weather<--



___main method to adjust frequency: adjust height of lower section above ground. This is using the capacity (coupling) to the ground, rather than changing the physical lengths.

___alternate method, if the above is insufficient: adjust the lengths of the horizontal bars.

n6bt-Gen7-40-x5-dwg8-r1

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This is a full size 20, then loaded for 40, so it can be a 2-band antenna.

The tri-pod legs are **telescoping painter's poles** (available from Home Depot), making this fast and easy to install and then take-down.



Gen-7 8040

80/40 meter vertical w/motorized Tornado drive*

for permanent installations, DXpedition, portable

.375" x 60" exposed (72" total length)

.5" x 36" exposed (72" total length, 1" inside .75")

.625" x 35" exposed (72" total length, 1" inside .875")

.75" x 36" exposed (60" total length, 1" inside 1")

.875" x 23" exposed (60" total length, 1" inside 1.125")

1" x 36" exposed (60" total length, 13" inside 1.25")

1.125" x 23.5" exposed (47" total length, .5" inside 1.375")

1.25" x 23" exposed (36" total length, .5" inside 1.5")

1.375" x 12.5" exposed (18" total length)

1.5" x 12" exposed (18" total length)

1.625" x 6.5" exposed (18" total length, .5" inside 1.875")

1.75" x 3" exposed (18" total length, 15" in 1.875")

15"

9"

12"

12"

Tornado drive with internal 40 mtr switch

1.875" x 24"

1.75" x .25" fiberglass x 8" inserted

1.875" x 6"

1.75" x .25" x 48" Fiberglass Tube

1.875" x 6" w/(2 or 3) welded guy ears

1.875" x 6"

1.75" x .25" x 8" inserted

1.875" x 63" exposed (72" total)

2" x 31.5" exposed (36" total)

1" x 4.5"

.875" x 4.5" exposed (9" total)

ring far side support

.75" solid fiberglass rod ring support (telescopes inside .875")

2.125" x 9" (4.5" over 2")

2" x .25" x 14" Fiberglass Tube

2.125" x 9" (4.5" over 2")

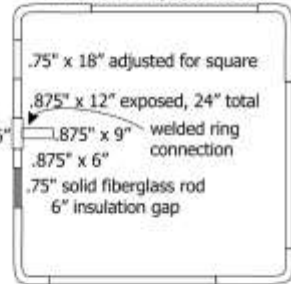
2" x 24" w/1.875" full inner liner

NOTE

drawing is not to scale

Ring is approximately 89.5" each side and 86" on side with fiberglass support

.75" x 72" side tubes are inserted into corners and adjusted to tune



n6bt-Gen7-8040-x5-dwg1-r2

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*patent pending on Generation-7 design

2-Band 80/40 Vertical

Full size 40 with open ring;
loaded to 80/75 using
motorized Tornado Drive.

Total footprint is
approximately 7'x7',
which is the open ring
dimension (~full size 40)

plus guy attachment points
which can be very close,
or use (2) rigid guys that attach
at approx 8' from center.

80/40

A full size vertical for 40 with an full size 40 mtr open ring, making a full length vertical dipole on 40.

A Tornado drive (motorized inductor pair) is added at the feed point for full coverage on 80/75 meters.

This can be tilted over and the ring hinged to stay parallel to the ground.



Other small space antennas

Several types of flagpole verticals

some use a tuner at the base,

some use tuner at the rig,

most use buried radials;

the OCF does not.



Where is the best location for a tuner when we are using a non-resonant antenna on multiple bands?

___A. At the rig

___B. Where the coax enters the house

___C. At the antenna feed point

Should we use a balun on a non-resonant antenna like a flagpole??

- ___A. Yes – at the feed point, in front of the tuner at the antenna
- ___B. Yes – at the feed point, after the tuner at the antenna
- ___C. Yes – at the feed point and using the rig's tuner
- ___D. Yes – at the point where the coax enters the house, using the rig's tuner
- ___E. No – makes no difference
- ___F. Yes – it depends

If possible, try to utilize terrain to your advantage.

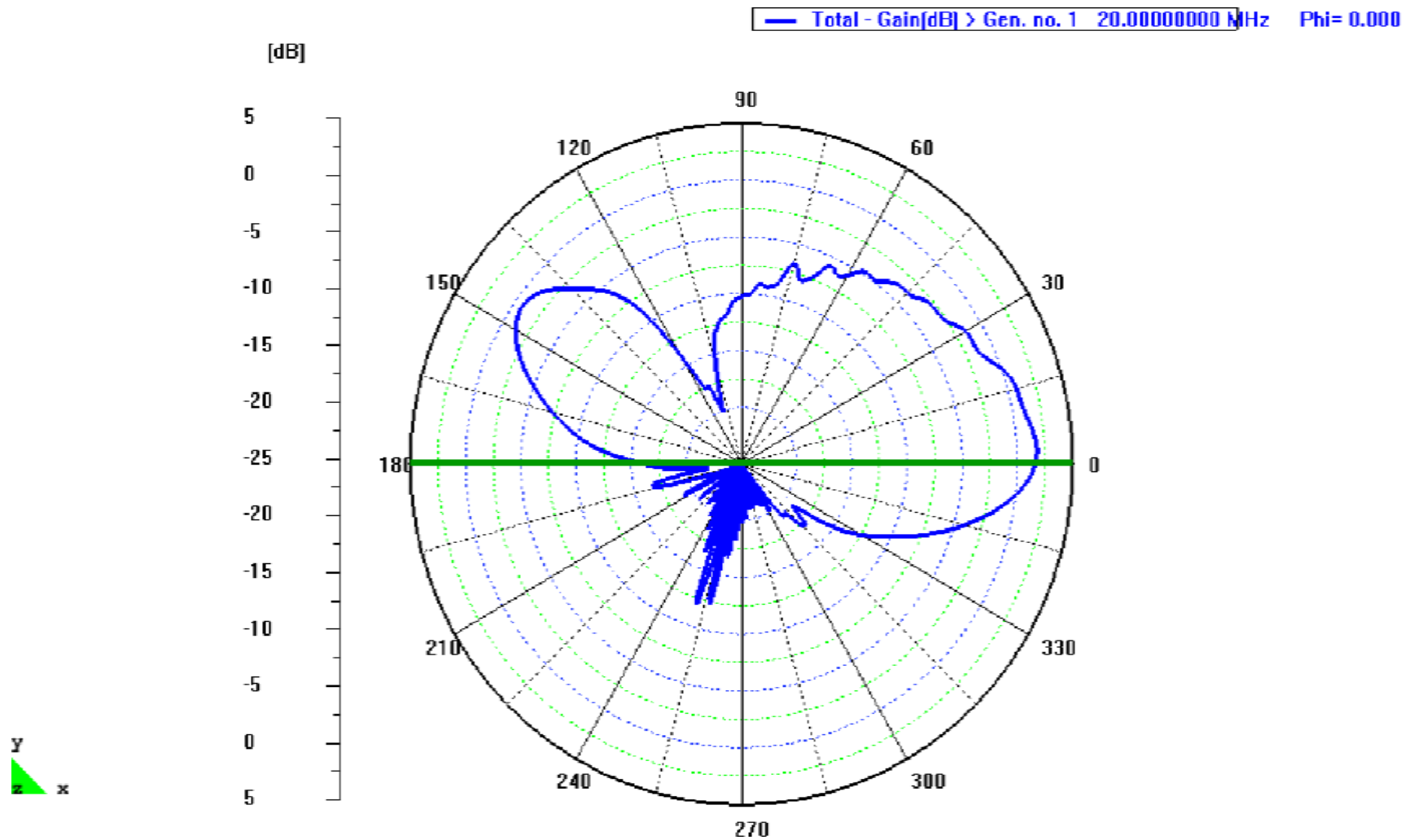
For verticals, place them adjacent to sloping ground, or even right at the top of a hill.

Since 2014, have performed empirical tests of verticals (and dipoles) over several types of ground, flat ground, sloping ground and salt water using helium balloons first, then (3) drones.



Effect of Ground Tilt on Vertical Antenna Radiation Pattern

Steve Stearns, K6OIK
January 3, 2018



New software confirms that a vertical adjacent to sloping ground will have the take-off angle lowered a bit over 1° for each degree of slope.

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Perhaps you can locate a vertical adjacent to sloping ground!

Remember that HOA and the trapped dipole on the roof?

Was that dipole very effective, or efficient?

Whichever, it did one thing → it got him on the air.

Just how efficient is a trapped dipole?

Let's fly through the pattern and see what we find.....



Yuneec Typhoon H with horizontally polarized
XG-3 test oscillator



Drone ready table down range

Step 1 - measure the trapped driver element to a full size dipole

Trapped 20 dipole

- _All joints were cleaned
- _Dipole center was separated inside the traps for full size
- _Full size dipole in same position as trapped dipole
- _Full size has the same balun/feed point/center as the trapped dipole, then added telescoping sections

Full size 20 dipole



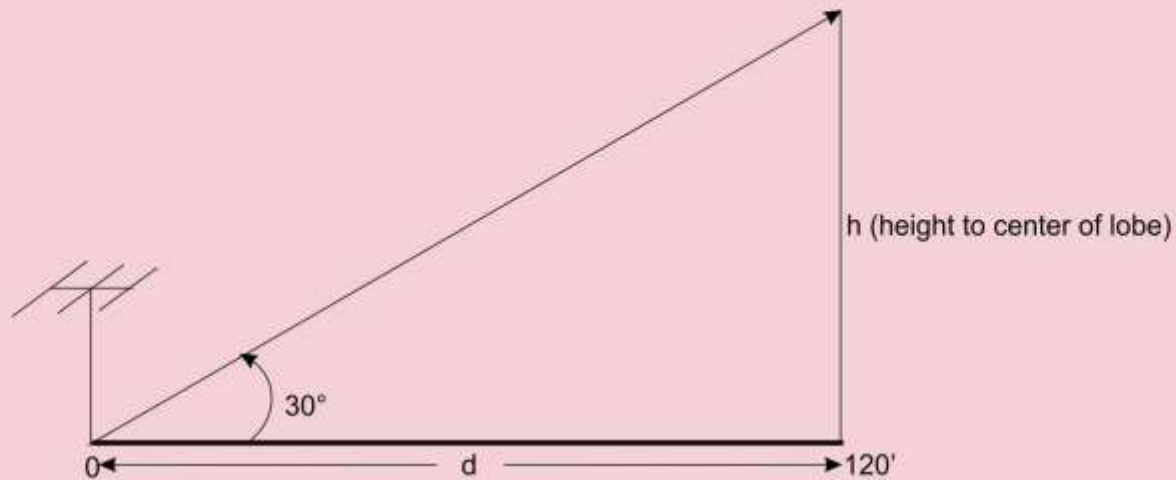
Feed point: 2-ferrite core with teflon coax balun

The candle (reference) antenna is 6" above ground, horizontally polarized, $1\frac{1}{2}$ wavelength distant to the side and rear.

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How high do we need to fly the drone to measure at the main lobe of our antenna under test?
The test antenna is on 20 meters at a height of 35', which is 0.5λ ; therefore, the antenna should have a single lobe centered at 30° .



- _ Distance from antenna to measurement point is $>1.5\lambda$ (end of near field).
- _ At 20 meters, one wavelength = 70', so we need at least $70 \times 1.5 = 105'$.
- _ Let's go a bit farther to 120', so how high do we need to fly to be at 30° ?

From the Pythagorean Theorem, opposite side/adjacent = tangent of unknown angle $\Rightarrow h/d = \tan 30^\circ$

We know d (120') and $\tan 30^\circ$, so we then use $h = \tan 30^\circ \times 120'$ (trig table shows $\tan 30^\circ = .577$)
 $h = .577 \times 120'$
 $h = 69.28'$

We want to go past the expected peak (at 70'), so let's fly to at least 45° , which is 120'.

$\tan 45^\circ = h/d$; $\tan 45^\circ = 1$, so then $h/d = 1$ or, rewriting, $h = 1 \times d$ $h = 1 \times 120$; therefore $45^\circ = 120'$ flight height

Step 1a - measure the trapped driver element to a full size dipole

Trapped 20 dipole



Full size 20 dipole



Spectrum analyzer with dual inputs:
"candle" and antenna under test

- ___ Drone flown to 150' height on each pass.
- ___ Analyzer was in MAX HOLD for each pass.
- ___ Pass of up/down/up/down was within 0.1dB each cycle.
- ___ Candle antenna was to ensure XG-3 source was constant.
- ___ Over all the passes, the dipole was 0.75 to 0.84dB below the full size dipole; therefore, the trapped dipole measured an average of **-0.79dB to full size.**

Step 2 - measure the tri-bander with all 3 elements



___ Measurements are taken between the trapped driver alone and with the reflector and director in place

___ Parasitic elements are rotated to horizontal from vertical after measuring the trapped driver alone

___ Drone flown to 150' height on each pass.

___ Analyzer was in MAX HOLD for each pass (max gain for 3el is at a lower angle than the dipole).

___ Passes ranged from 3.27dB to 3.52dB increase, averaging 3.42dBtd (3.42dB to the trapped driver)

___ Compared to the full size dipole, the tribander has -0.79 (trapped driver)

+ 3.42 (gain from 2 elements)

Actual gain to a full size dipole = 2.63 dBd

Notes: 1. the max gain on the 3el Yagi was at a lower angle (by several degrees) than the dipole due to

lobe compression for Yagis (gain antennas) lower than 1λ high; this Yagi was at $\sim 1/2\lambda$

2. what makes this antenna also "feel" like it has more gain is that it has pattern (i.e. F/B)

3. having a good 2.5dB over a dipole nonetheless is a noticeable improvement

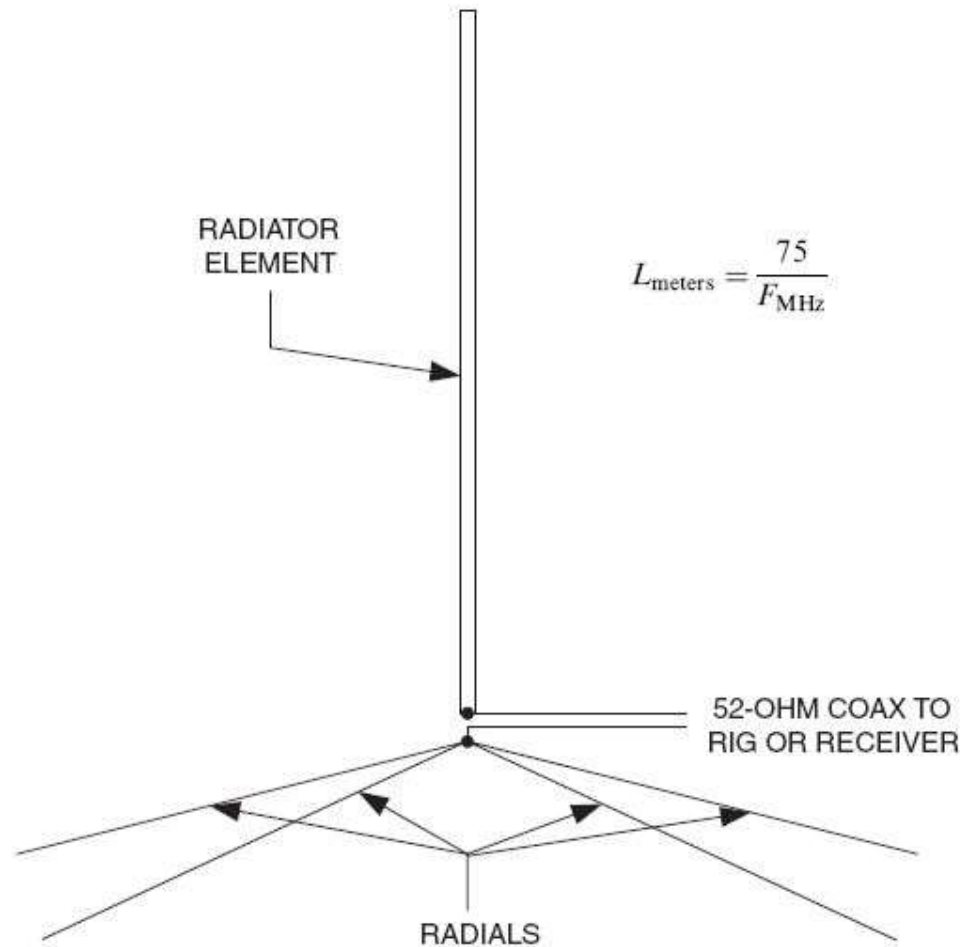
Overall, the trapped dipole being down even 1dB from full size on 20 provided a way to get on the air with an antenna that was fairly efficient, albeit the difficult installation.

It is also important that although the dipole is only a foot or so above the roof, it is outside.

Back to...

what can you make that will work well?

Classic vertical design that we followed for years and it left a lot on the table.

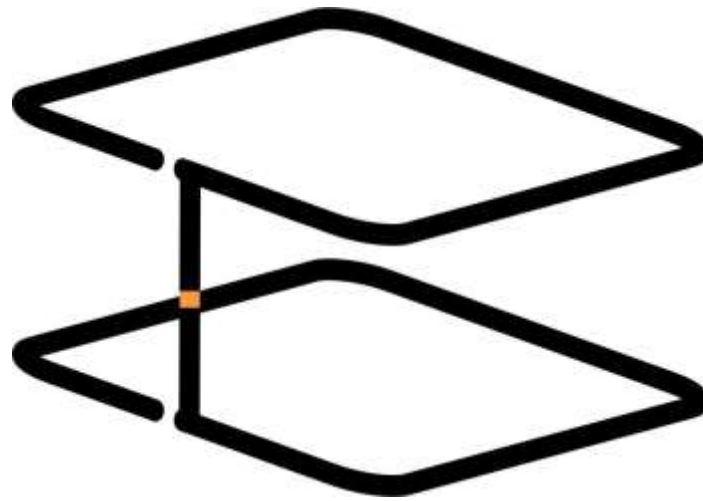


Best to make a vertical without ground contact

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Unless you can install a comprehensive ground radial system – ref: N6LF QEX

If you can work with aluminum tubing and can do some computer modeling, you can make a ZR design for any band.



Dr. Joe Boyer's 20-mtr proto-type
3' tall vertical radiator
approximately 1/2 wavelength of **copper tubing**,
fed at the center of the vertical and matched using a hairpin.

The 3-band ZR-3 for 20-15-10 meters.

The vertical sections total 6' and the rings make up
the remaining length for a full-size dipole.

___ No loading coils, no traps

_____ High efficiency

_____ Hairpin match and fed with a 1:1 balun at
about a 45° angle to the vertical.

Monoband could be modeled, but not the 3-bander, so
15 and 10 were done real-time
(thanks to Ken, K6HPX for his great assistance).

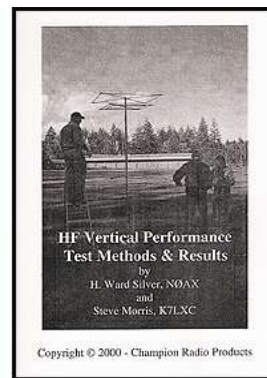
It is technically magnetic on 20, as the radiator is less
than 10% of a wavelength.

It is very quiet and a great performer.



Reviewed in QST, March 1998

and also by K7LXC and N0AX and N0AX



If the ZR is too complex to build,
you can make a Sigma style.

The Sigma is also a center-fed vertical dipole like the ZR, but the open-ended rings are replaced with "T-bars" (top and bottom)

Easy to model and can be full size with the vertical section lengths adjusted for a feed point of 50 ohms. It can also be shorter and center loaded with a feed point of less than 50 ohms and matched with a simple hairpin.

High efficiency and excellent performer.

Feed point, hairpin matched

This is a 2-element parasitic array:
driver on left, reflector on right,
aimed at Asia, Western USA.

Note: the reflector also has a hairpin match across the feed point. This is used to tune it to the right frequency using a balun. After the balun is removed, the hairpin remains across the parasitic element feed.



Jamaica 2001, Sigma 40XK

Simple mounting made from ABS for adding coils at the center and also a hairpin match with a 1:1 ferrite bead balun.



The Sigma can be made multi-band by setting the lengths for the highest frequency and equally loading each half at the center (for the bands desired). One hairpin matching the lowest band will work for all the bands.

Simple to make - equal vertical sections and equal T-bars. Needs to be a couple feet above ground - more is fine, up to $3/8\lambda$.

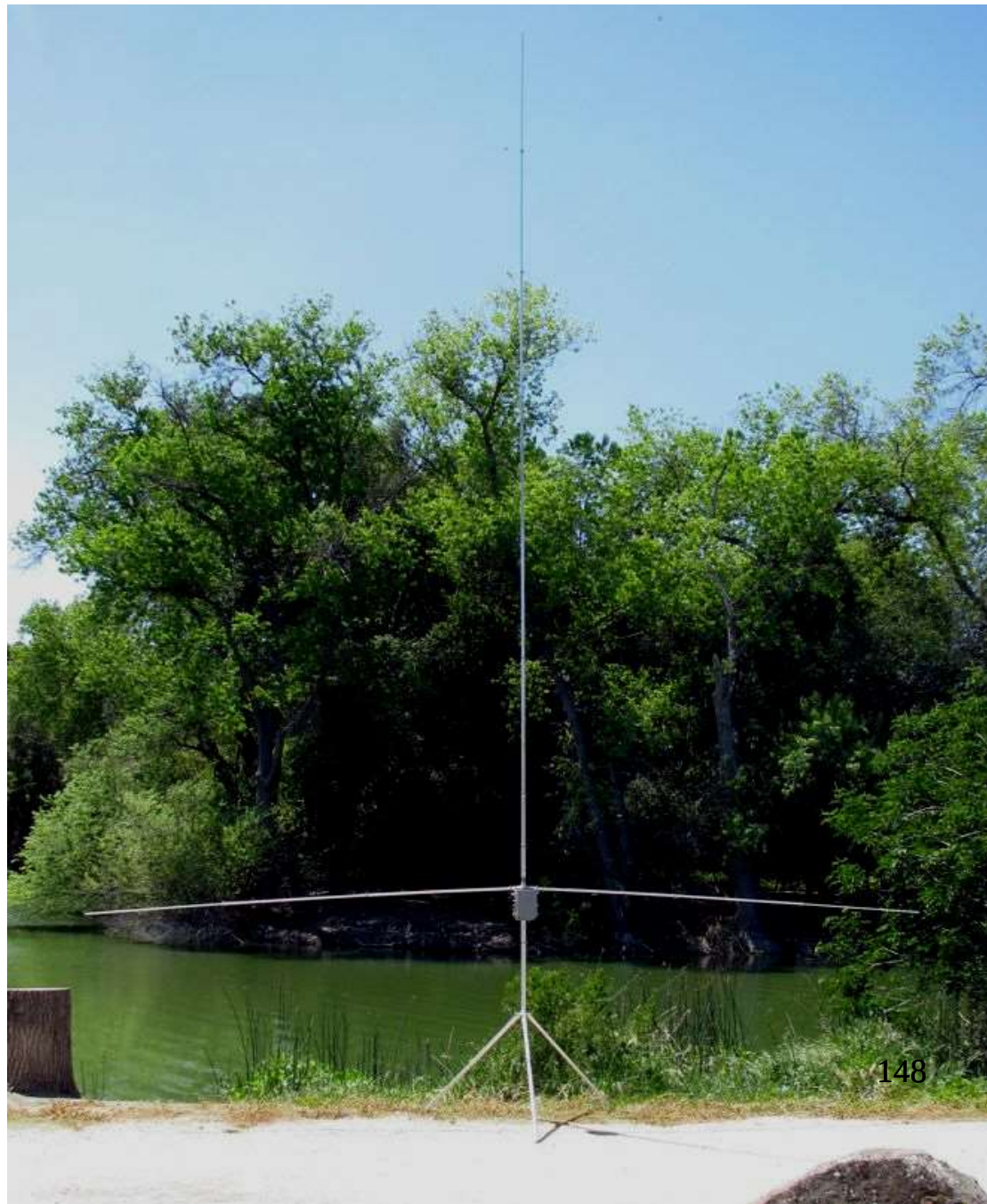


In 2' sections, it is excellent for portable.

Typical Bravo Series (40-10 mtr)

Since 2010, the Bravo has been produced in many models from 80 meters on up: single band, 2 and 3 band, 5-band, manual and relay switching.

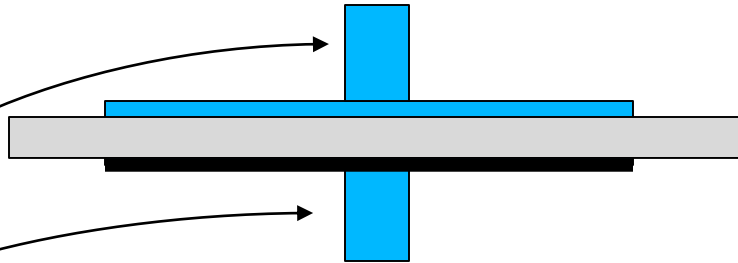
Originally developed for Team Vertical on Eleuthera, Bahamas.



Both of these designs model accurately and are high efficiency.

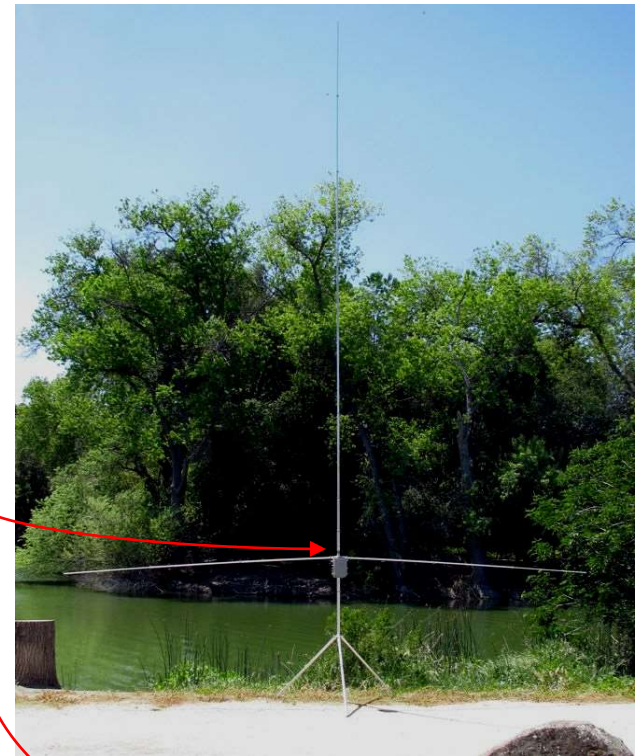
The most difficult part in building is when you need to change direction (90°).

If you cannot weld a tubing type "cross connection", use two lengths of 90° angle stock and weld them together.



Alternatively, drill through and use flat head screws to secure the two pieces at a right angle.

Clamp the shorter vertical to the antenna at the appropriate location; then, clamp the horizontal to the cross piece.



Another method for making the 90° junction, plus spreaders for an open ring counterpoise.

This is a 5-way PVC hub that is most often used to make furniture.

All five (5) receivers accept 1" PVC (this is an I.D. measurement and is 1.25" O.D.)

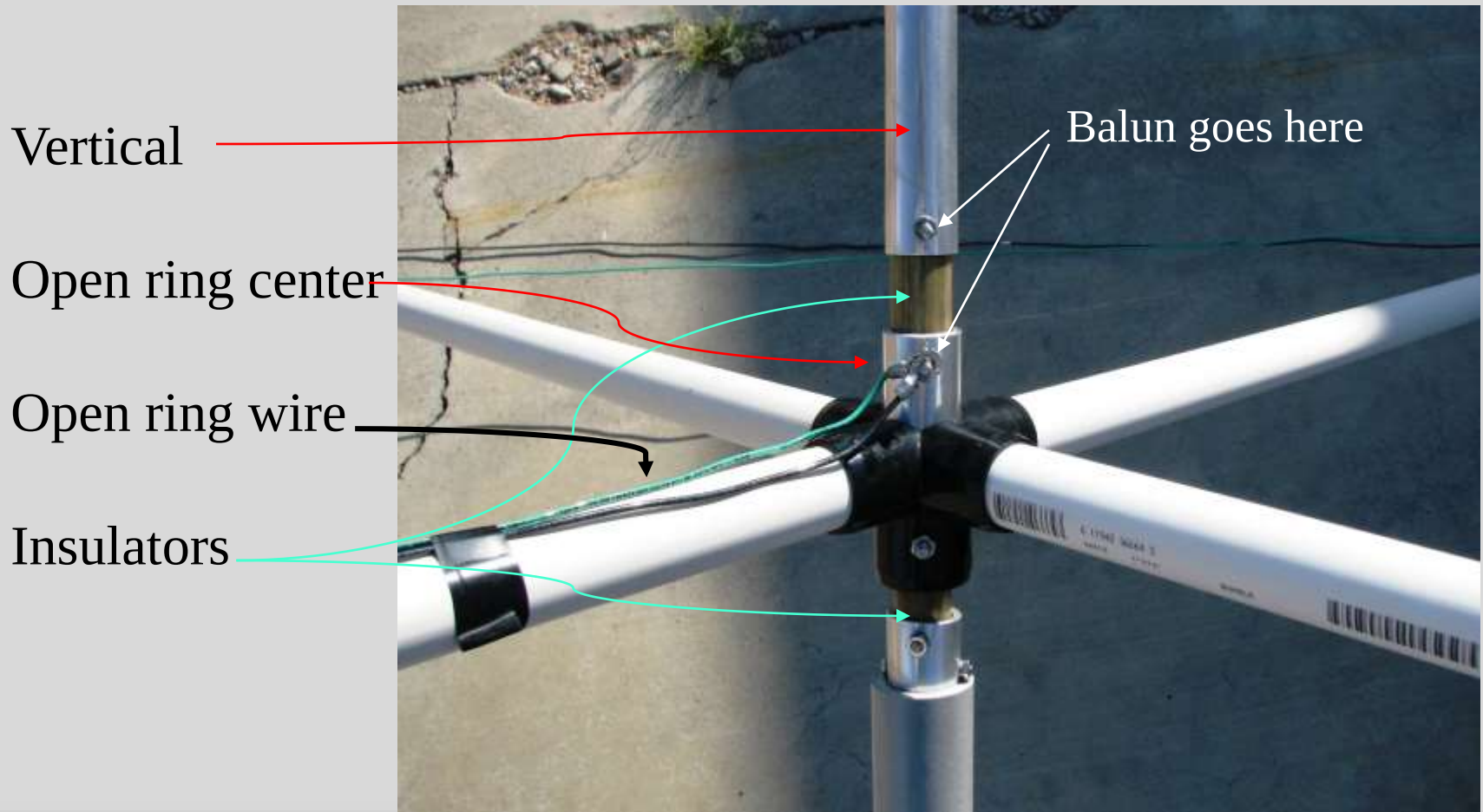
It will be necessary to make a hole on the bottom of this hub to use as an antenna hub.

Use a 1.25" hole saw style bit and go in from the bottom.

You will then be ready to finish the antenna hub...



Actual hub for a portable, single-band 20 meter vertical



Hub of proto-type multi-band vertical using open rings

(3) fiberglass spreaders, clamp-on spreader
mount and element bases (15 shown)

Full length radiators and full
length open rings
(only 20 and 15 meters so far)
Efficiency 98%

(power limited by the balun)





60 meters (5.3MHz)

Objectives:

19' tall radiator

Small/short

5' per side ring

Efficiency >80%

(3 sides, 4th is open)

Low cost



EV Series

2el rotatable

Without ground contact and no horizontal sections, multi-band vertical dipoles can be paired for a low profile, rotatable gain array.

This 2 element is manual band change for 20-17-15-12-10 meters.



How much loss is there in a vertical with unbalanced current and no balun?

Def: an unbalanced vertical is one that is asymmetrical



VSWR 1:1, but 0.9dB loss (20%) compared to balanced installation

15 mtr vertical dipole offset 30" = -0.9dB (drone measure @ 2λ , VSWR 1:1)

Efficient design is key and gain is hard to come by, so we don't want to lose it; therefore, feed a vertical with a balun to force current and isolate the coax feed line.

With current imbalance, the balun will heat up, but the system is more efficient than without the balun (you can test it using an infrared thermometer).



Loading coils - the best are air core.

Many coils are wound on PVC, or some kind of plastic (black) material; consequently, are you sure what it is?

Black might contain graphite = conductor (albeit poor)

Many products (e.g. PVC) come from Asia and the content is unknown.

Be cautious of using bungee cords for securing things at the bottom of an antenna, such as loading coils or capacitors for matching a tower.

They are black and can contain something conductive, then get hot, creating smoke and eventually melt/burn.

Where is the best location for coils?

Close to the center/feed point:

It is the highest current, lowest voltage,
requires the lowest inductance for resonance.

Moving coils farther away from the center/feed point:

current decreases, voltage increases, and
the inductance increases to maintain resonance.

Coil location can be determined so that the element is not resonant on other bands that might be near by.

When do you begin to consider the pattern, or when does it become important?

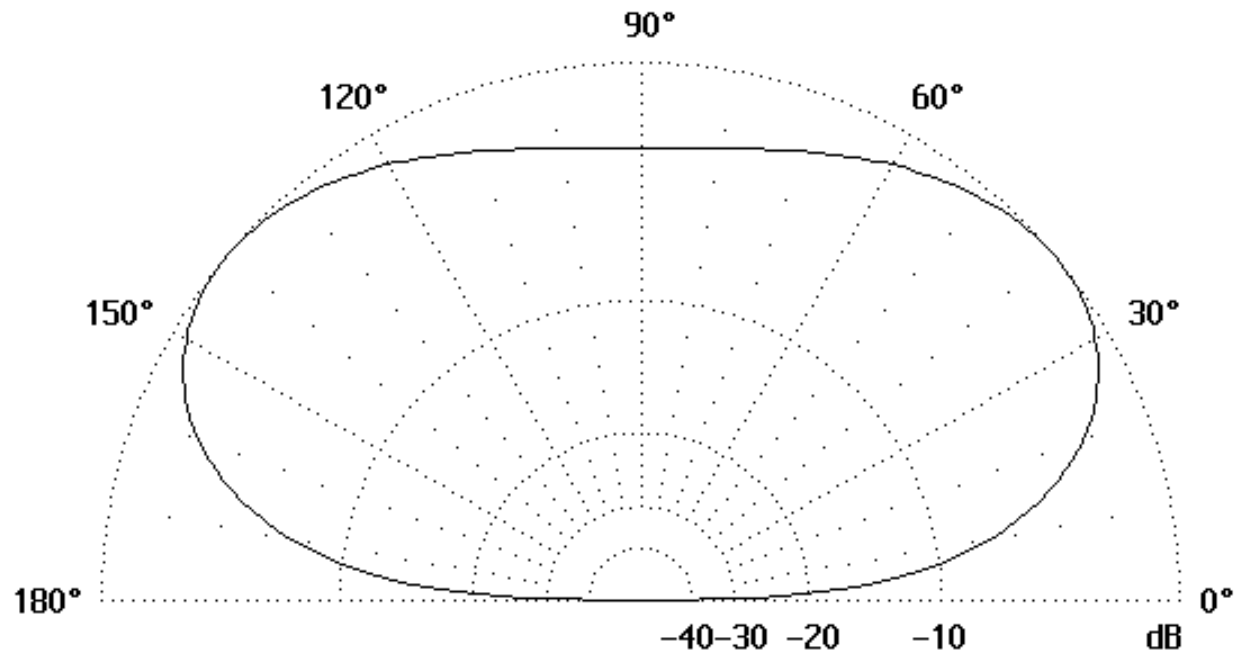
___Getting on the air with “something” implies that the pattern is most likely not much of a concern.

___Chasing DX, or contesting implies the pattern is important - the target zone of the antenna is the primary objective and rejection of other directions might also be important.

How do you get directivity?

Sometimes unknowingly!

Quick look at the popular a G5RV at
a typical smaller installation height of 25'
(remembering the plots earlier in this presentation)



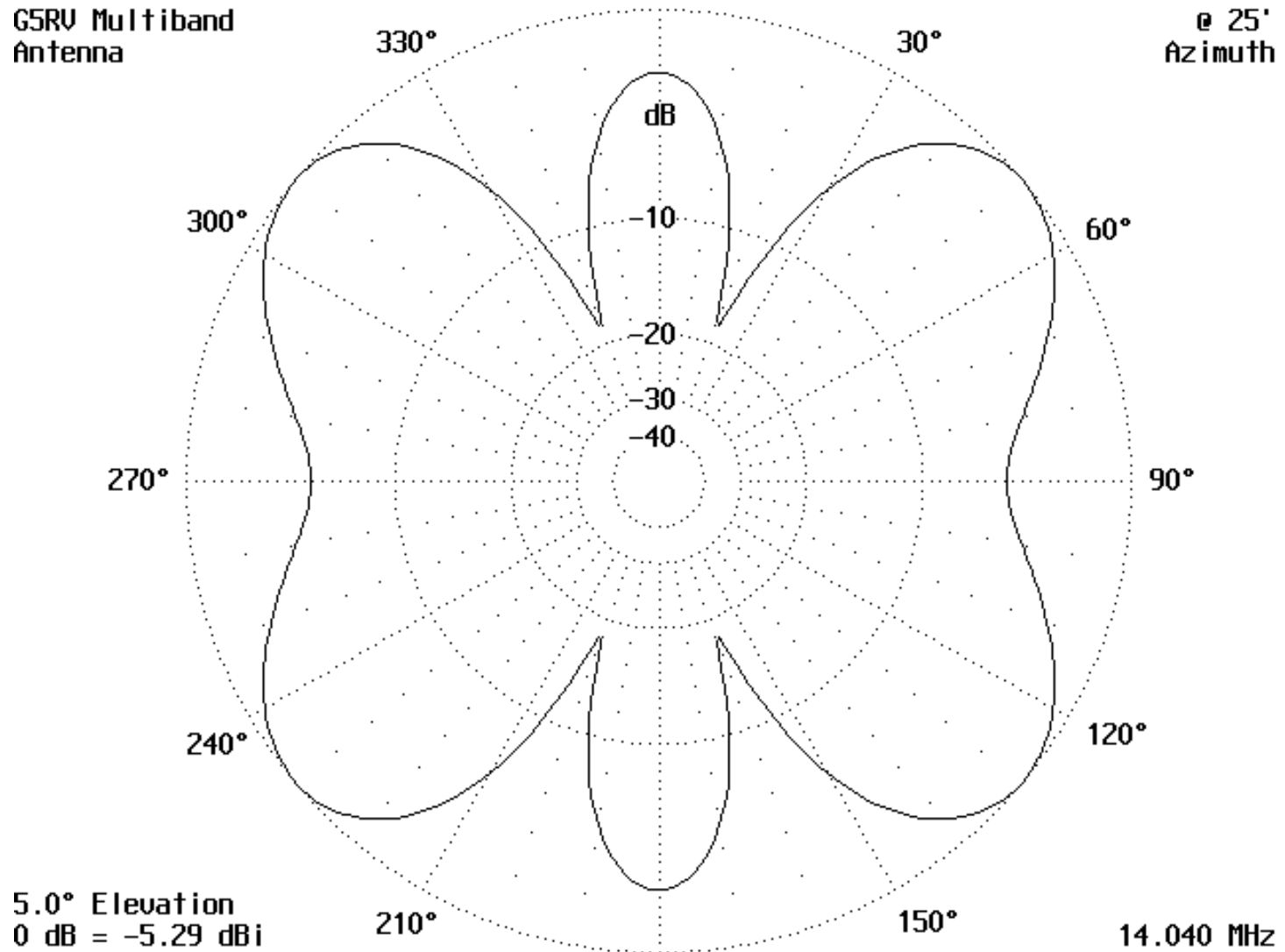
0 dB = 5.00 dBi

14.040 MHz

Take-off angle looks reasonable on 20 meters...
(looking end-on to the antenna, broadside view)

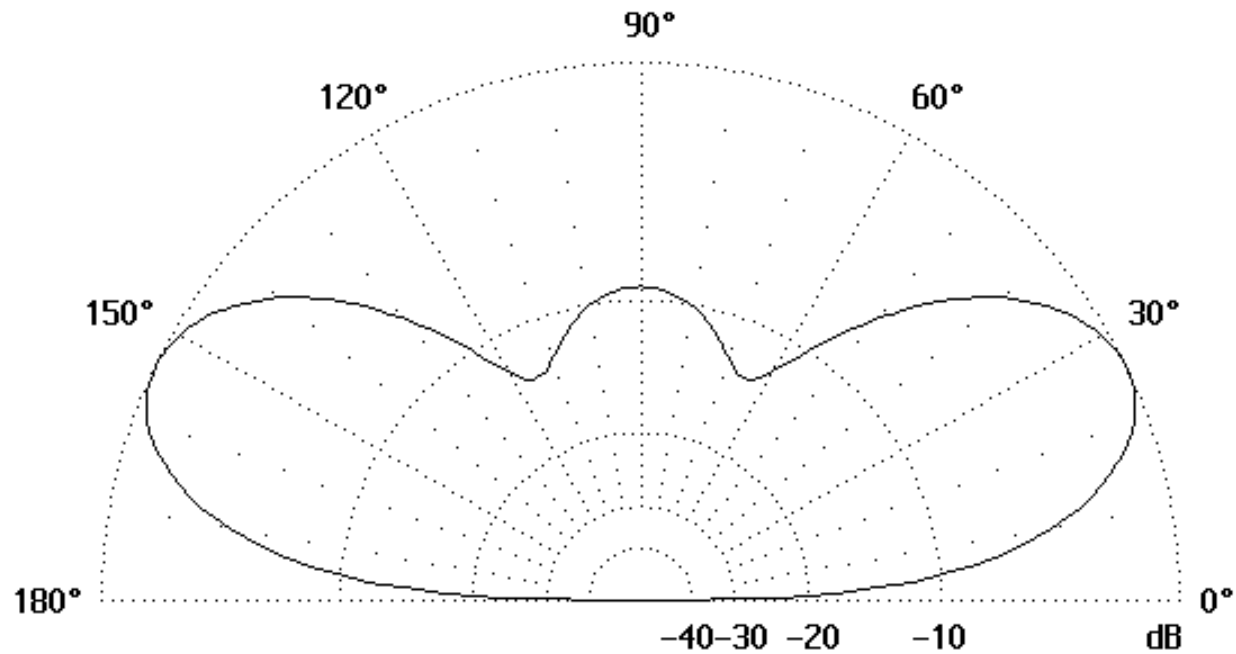
G5RV Multiband
Antenna

@ 25'
Azimuth



...until we look at the directivity.
(looking down on the antenna, azimuth view)

How about on 15 meters?



E l e v a t i o n

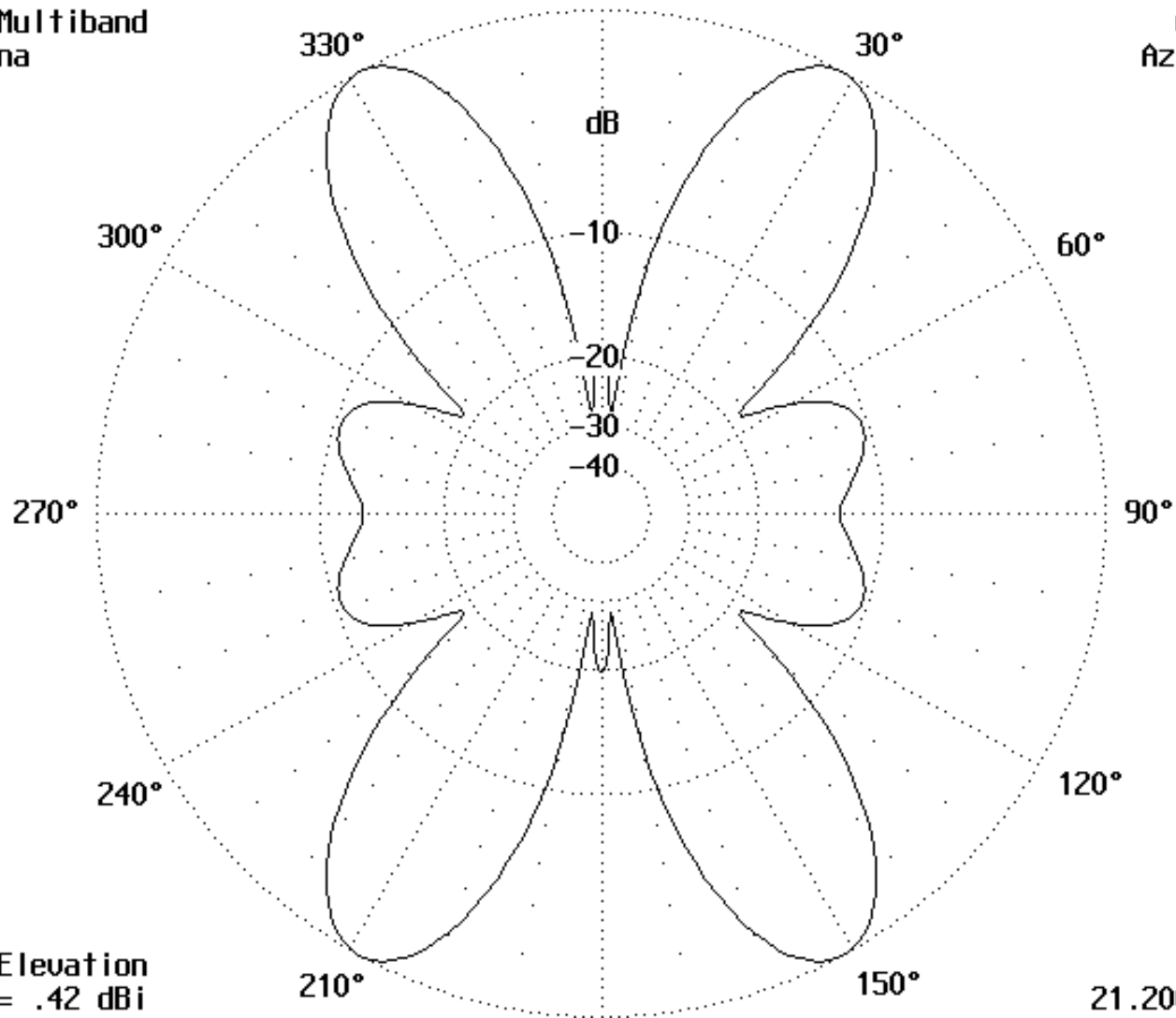
0 dB = -9.62 dBi

21.200 MHz

Take-off angle looks fine...

G5RV Multiband
Antenna

@ 25'
Azimuth



...but the directivity is probably not what you would want.

Watched a very good build-it video on Youtube for a fan dipole.

Then, the author pulled up new fan dipole to the top of his 40' tower to test it.

It came to rest about a foot from the feed point of a G5RV.

He then proceeded to run comparison tests between the two antennas.

The problem is that there were not two antennas, there was only one, with two feed lines.

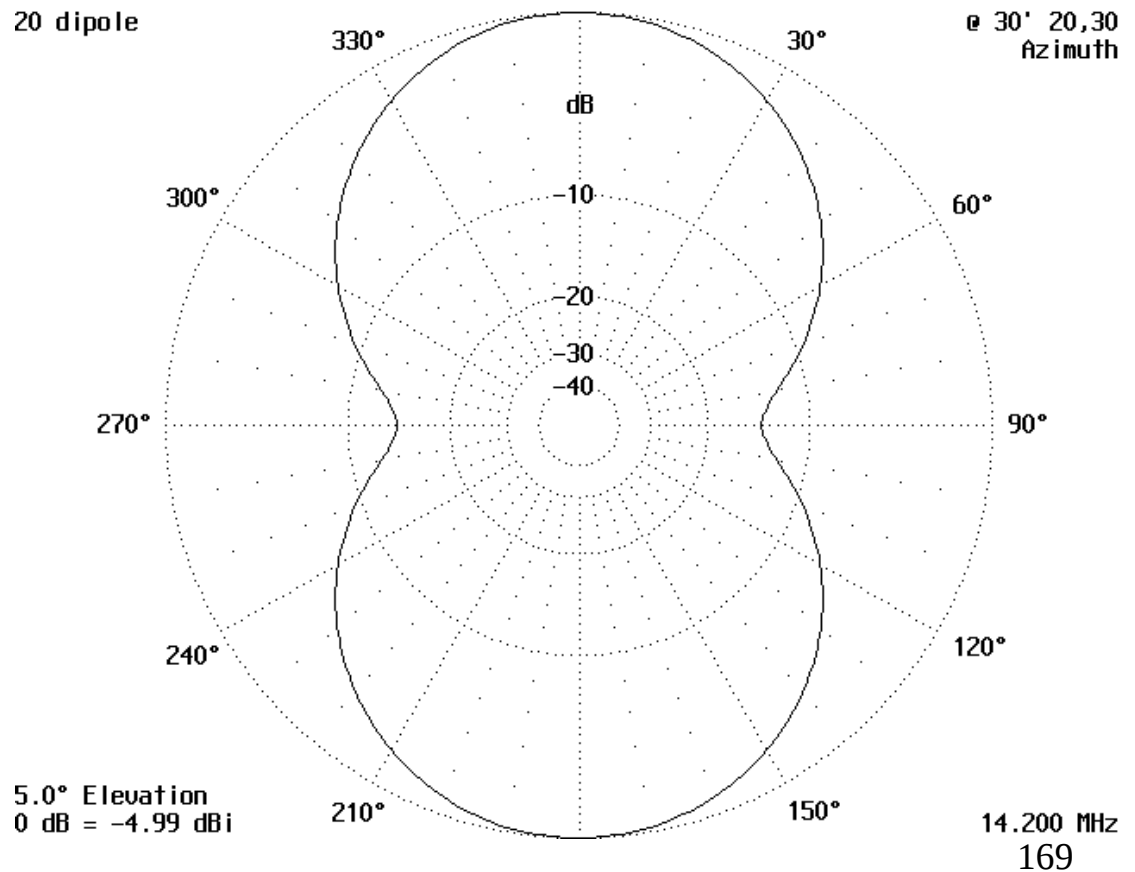
MAPS and Aliens

In general,
we study antenna patterns and
expect the antenna
to perform like we see in the plots.

If we put up a dipole, we expect it to have the classic figure-8 pattern:

Is this what we always get?

Why not?



The plots presume the antenna is “all alone”
but...what if it isn't?

Every antenna will “see” other objects within a certain distance from it.

Remember - although an antenna is a mechanical structure, it is first and foremost, an electrical device.

To operate as we expect,
(like the plots in books and on your screen)

an antenna needs to be in the clear
by a certain distance,
depending on the frequency of the antenna.

Let's introduce a new term:

“Stand-off Distance”

**This is how far the antenna is from any other surface or structure,
including
ground, roofs, walls
and other antennas or feed lines.**

Can you test if the stand-off distance is adequate?

M.A.P.S.

My Antenna's Personal Space

PROXIMITY

A starting point for a practical answer can be derived from:
how far can we space elements in a Yagi
and still have it be effective?

At least a $1/4$ wavelength.

$$40\text{m} = 35'$$

$$20\text{m} = 18'$$

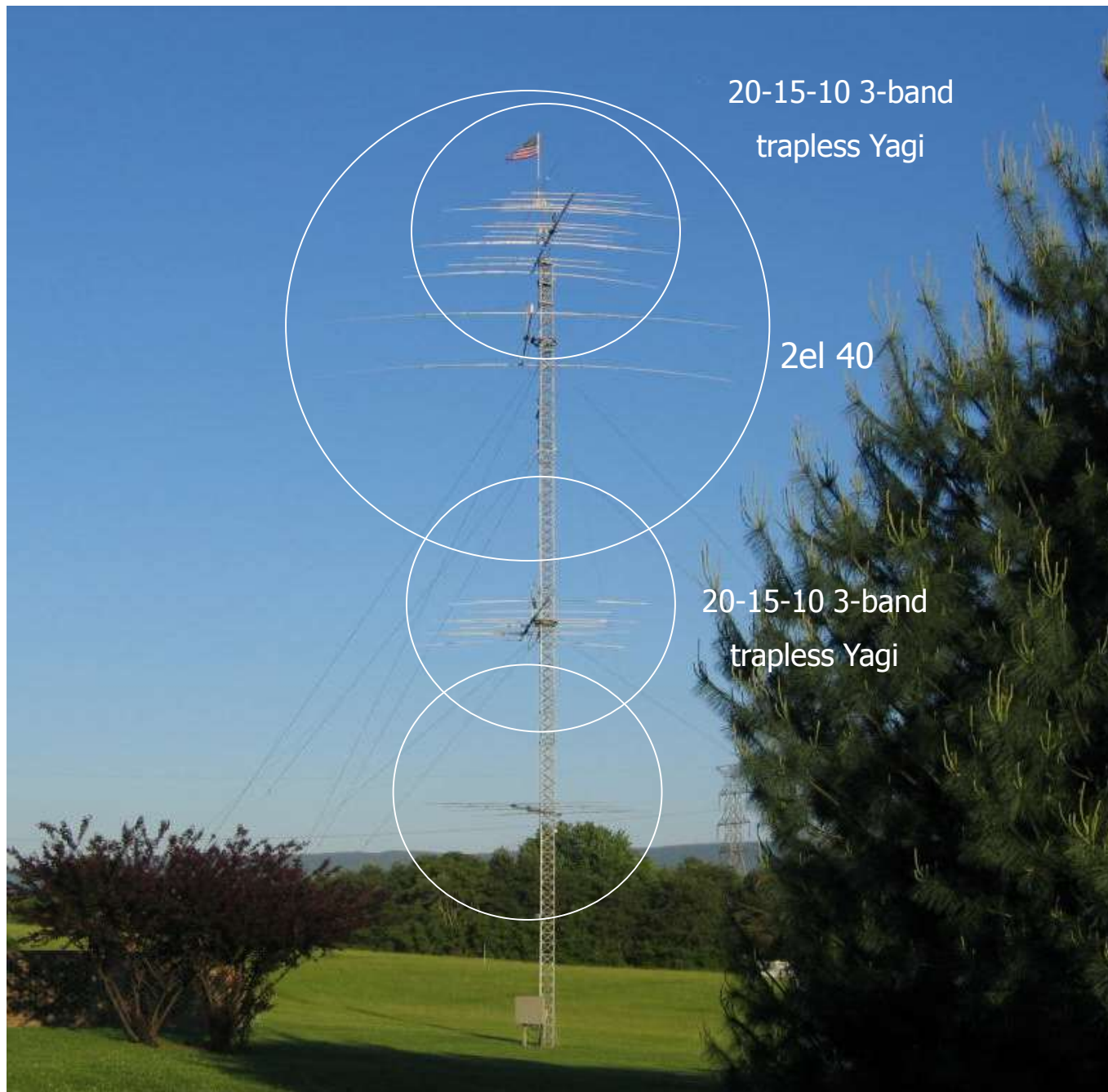
$$15\text{m} = 12'$$

$$10\text{m} = 9'$$

The catch is that this is in all directions -
all 3 dimensions (x,y,z)

a sphere around every antenna.





When we put up an antenna **and** there is an object within the antenna's stand-off distance,

a) we know that that object will interact in some manner with the antenna,

or, putting it a different way,

b) we know that the antenna we just put up will "see" that object in some way.

"What does our antenna (actually) look like?"

Our actual antenna is composed of the physical antenna we put up,
PLUS
everything within its stand-off distance.
(addressing only the antenna, not the pattern)

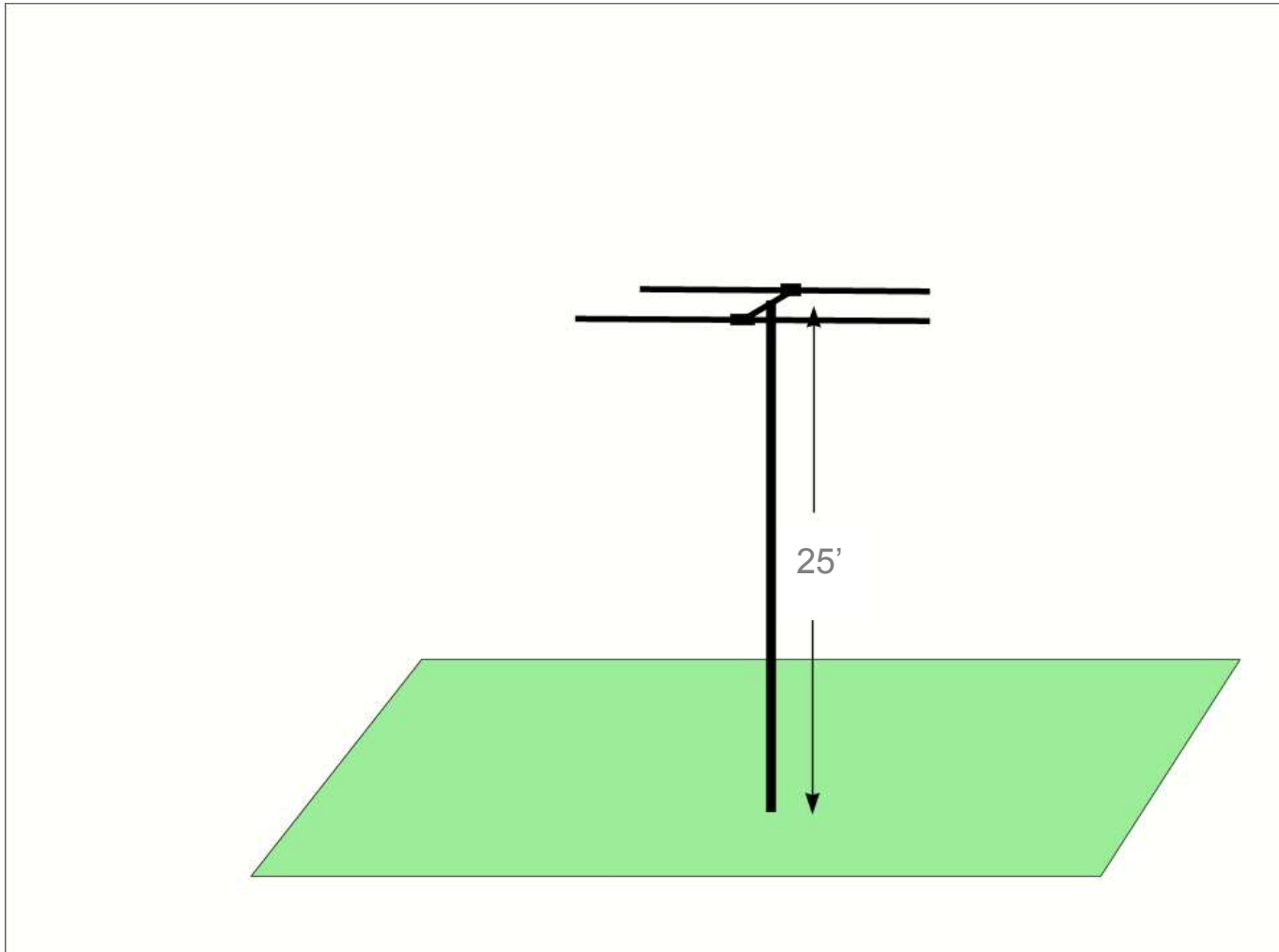
We have an **“Alien Antenna”**

It is unknown:

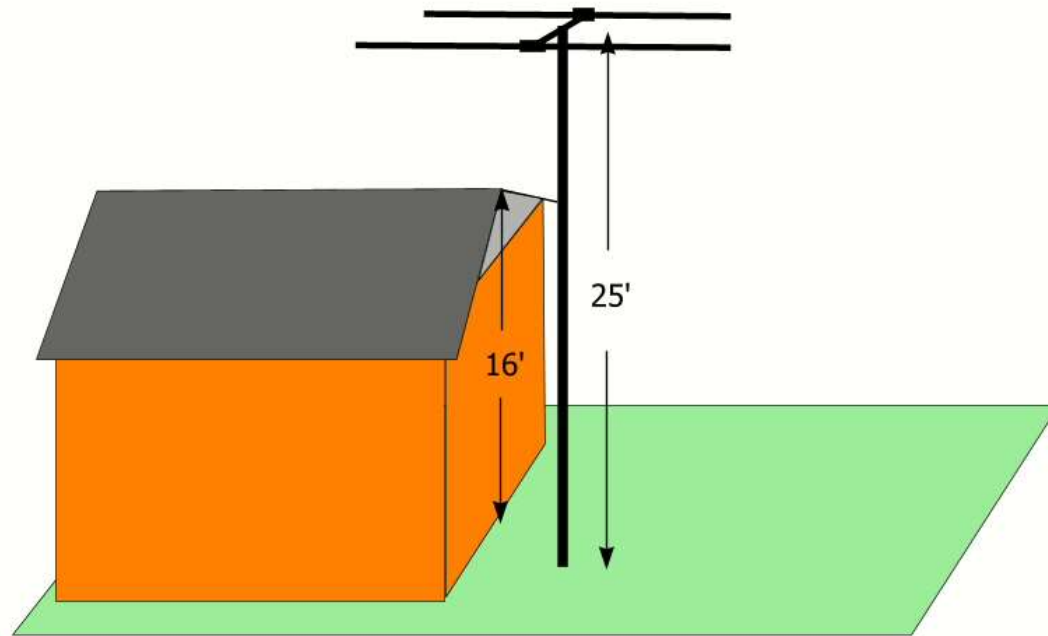
it is partly what we put up and part other things.

Example:
Height above ground

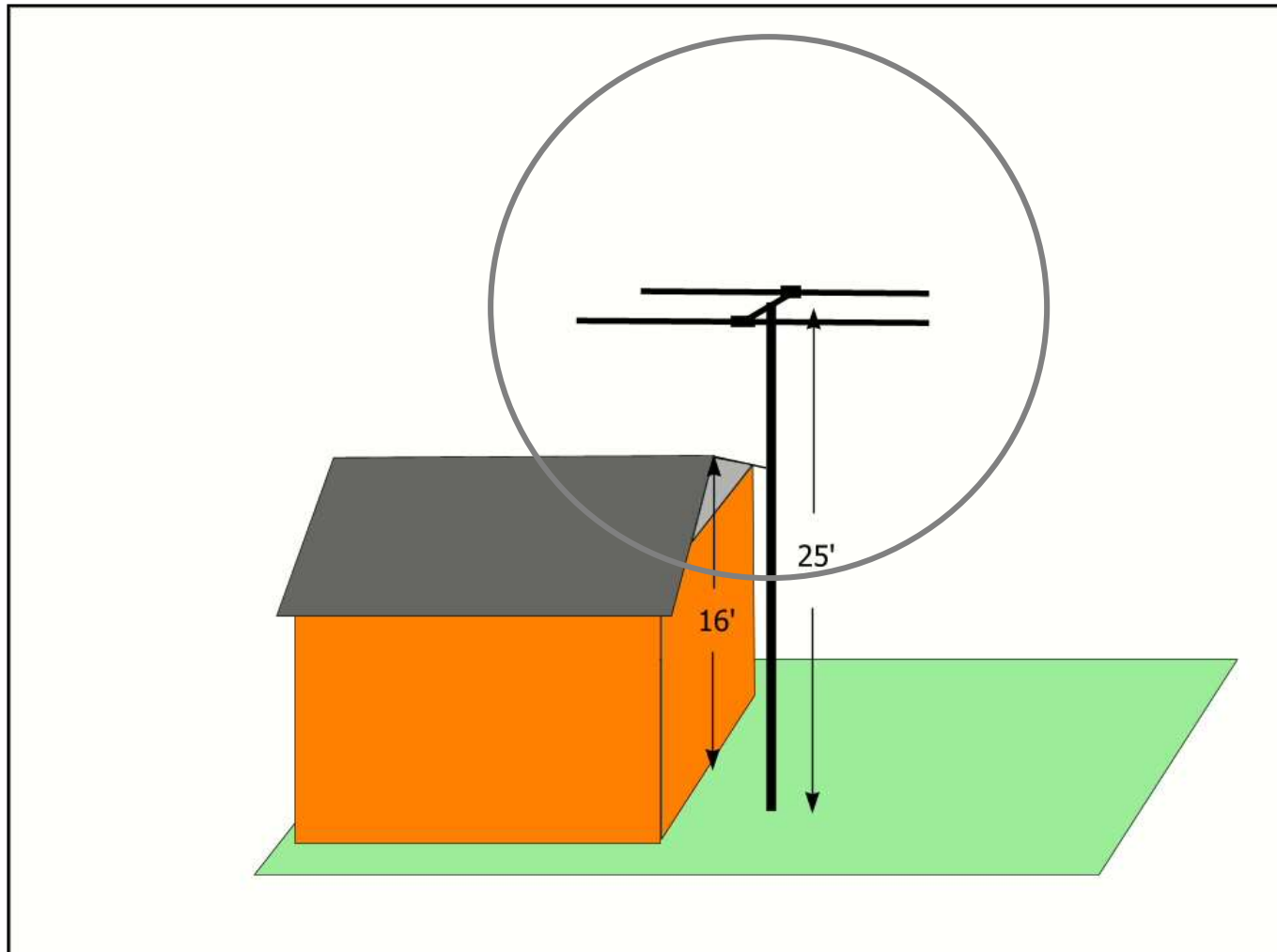
The antenna's height above ground is _____?



The antenna's height above ground is _____?



The house is well within the stand-off distance from the antenna.

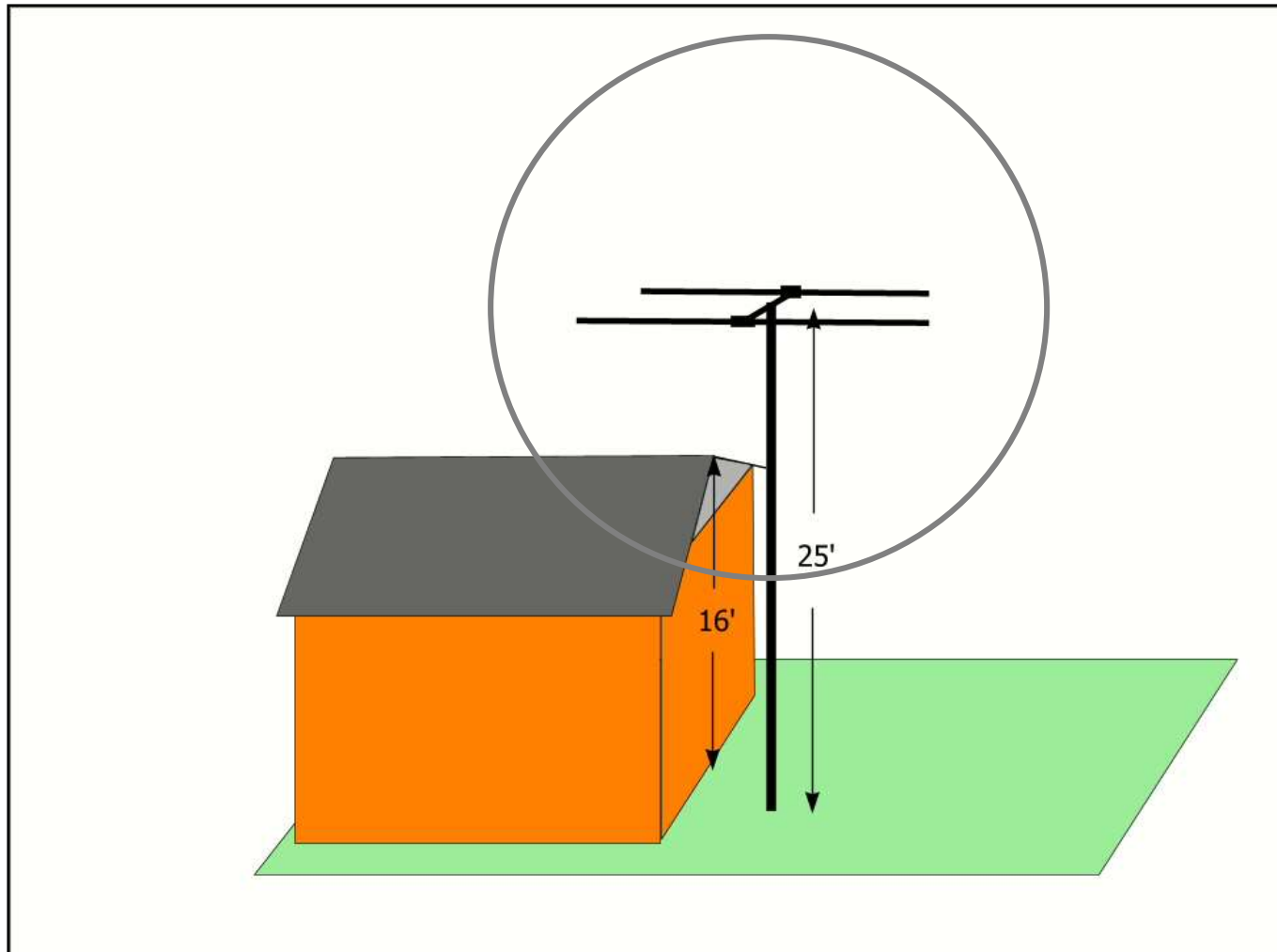


The antenna will certainly be affected by the house.

What typically happens when an antenna is in close proximity like this?

The frequency is pulled low
and
the feed point is also affected.

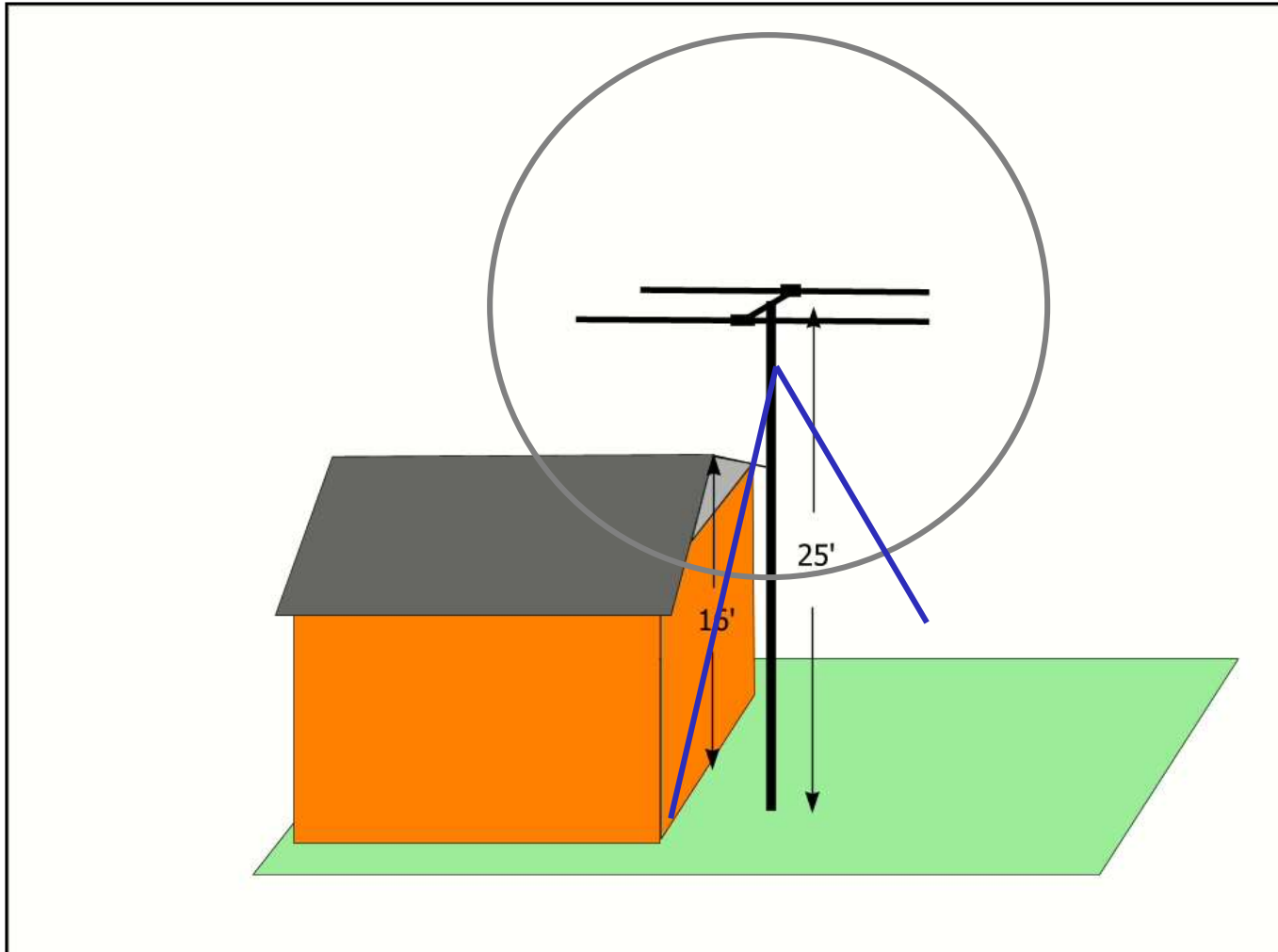
This is a simple example of an alien antenna, which includes the intended antenna, plus the affects of the roof (its composition), AC wiring, duct work, gutters, security wiring, etc.



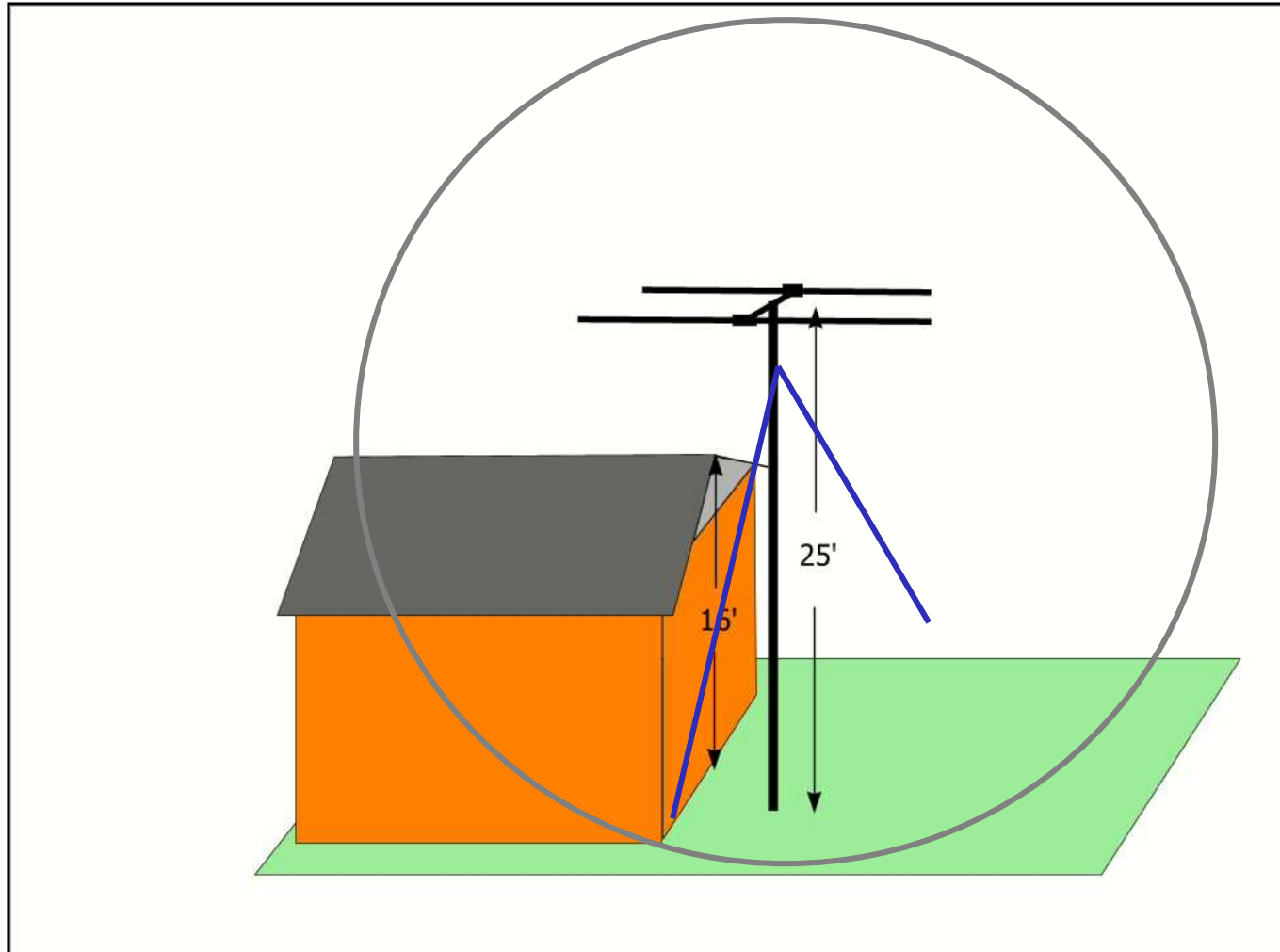
190

The antenna will absolutely be affected by the house, especially on 20 mtrs.

Let's add a 40-meter inverted Vee...



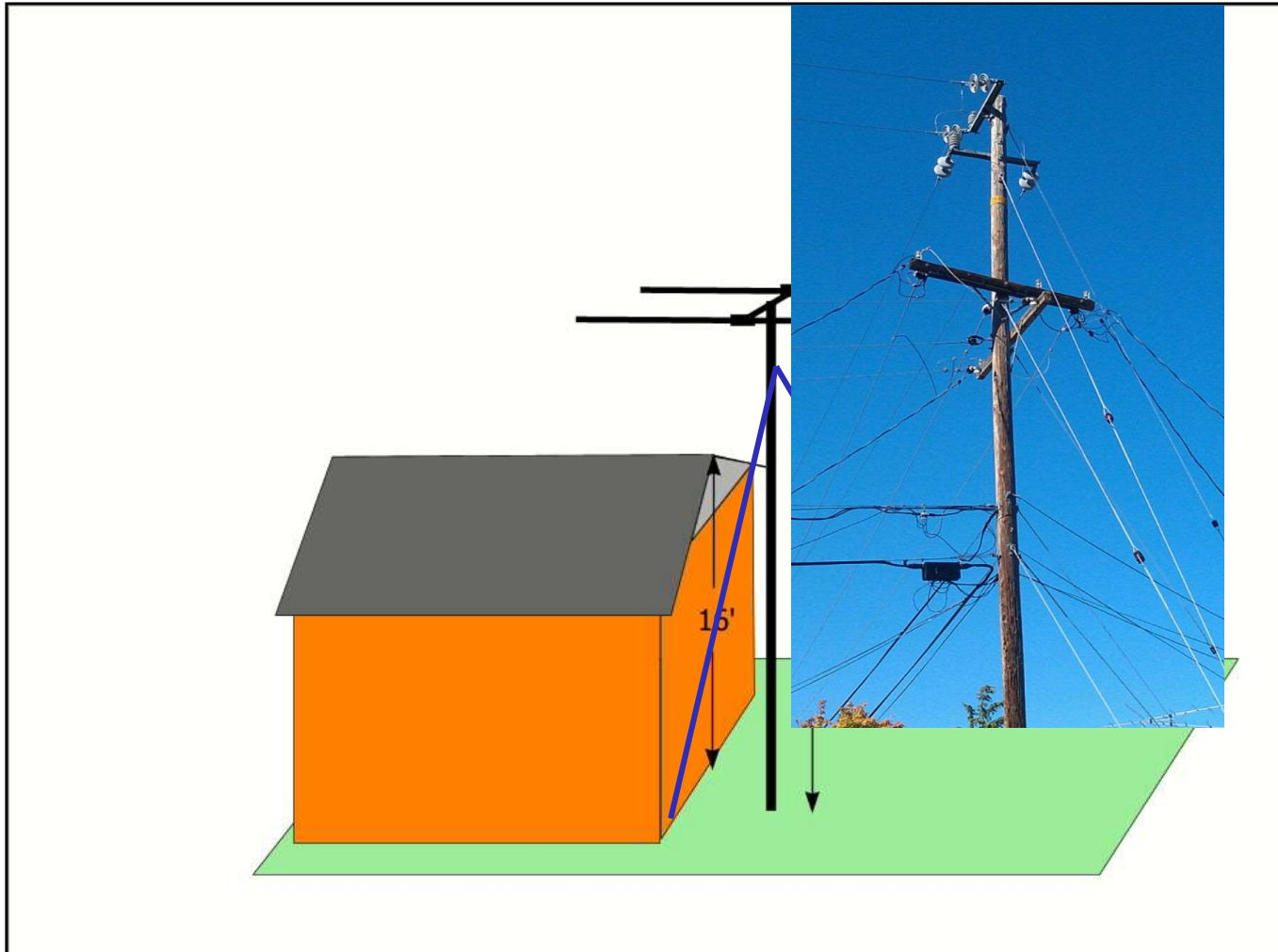
Just about the whole house and everything inside,
plus sprinklers.



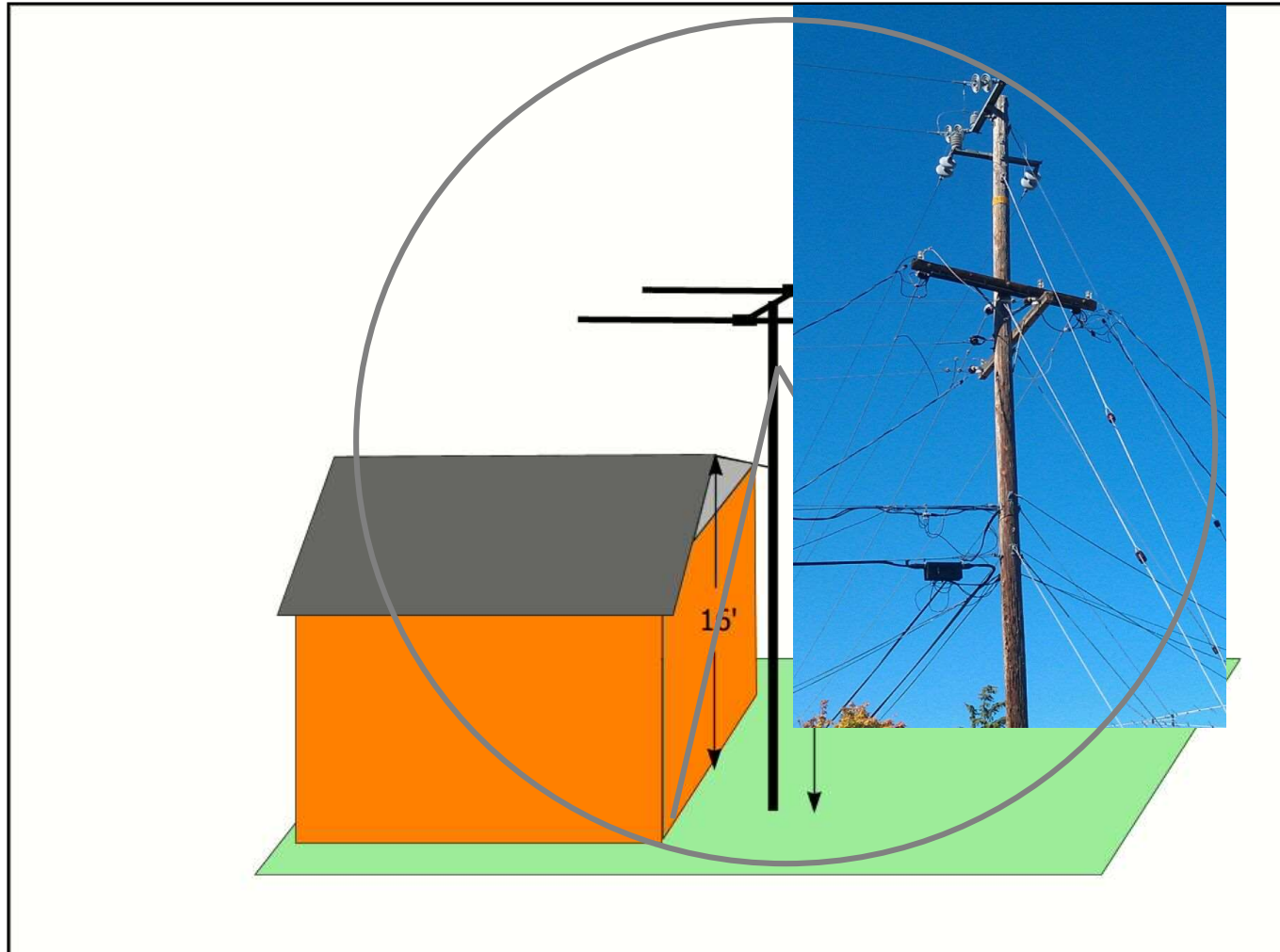
Let's add a typical power pole into the back yard...



Now to add the stand-off distance for 40...

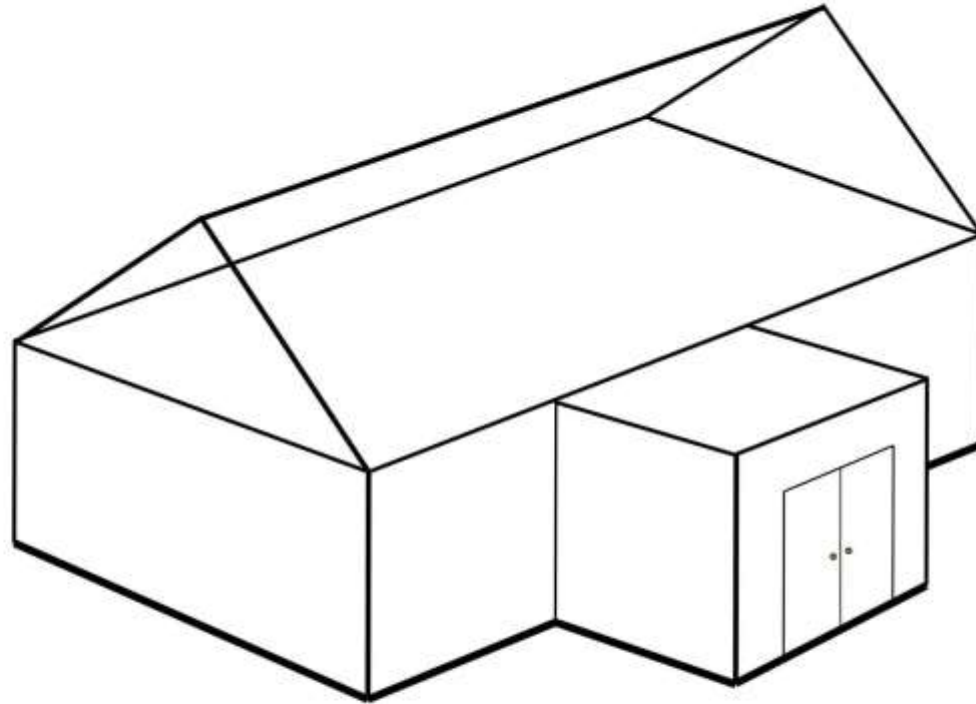


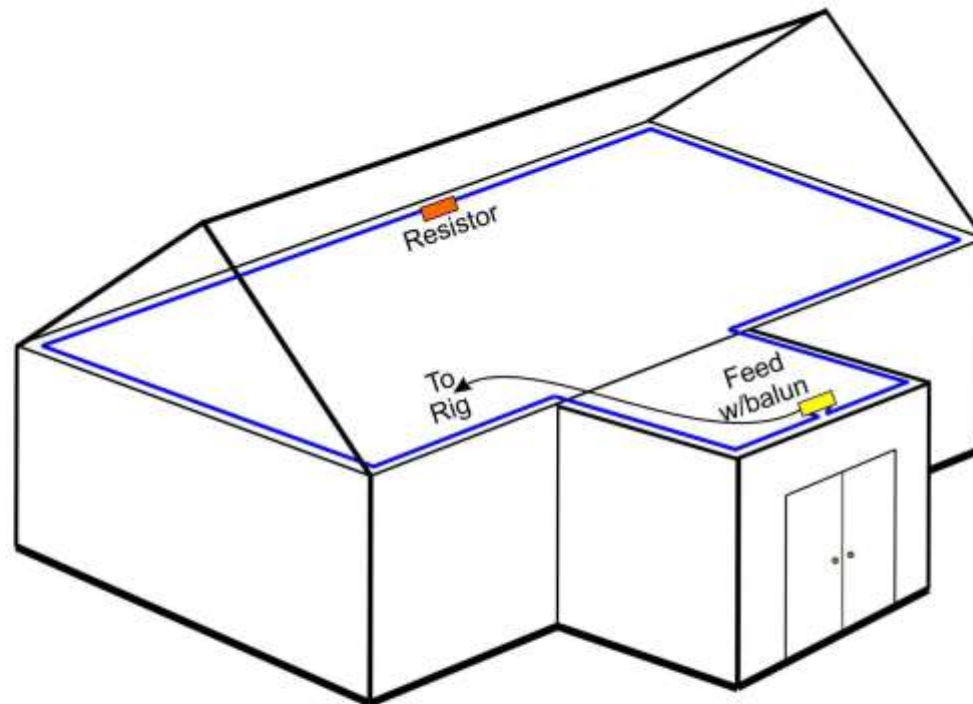
This is a real problem, as our antenna is truly an alien:
it includes the antenna, power pole and house.

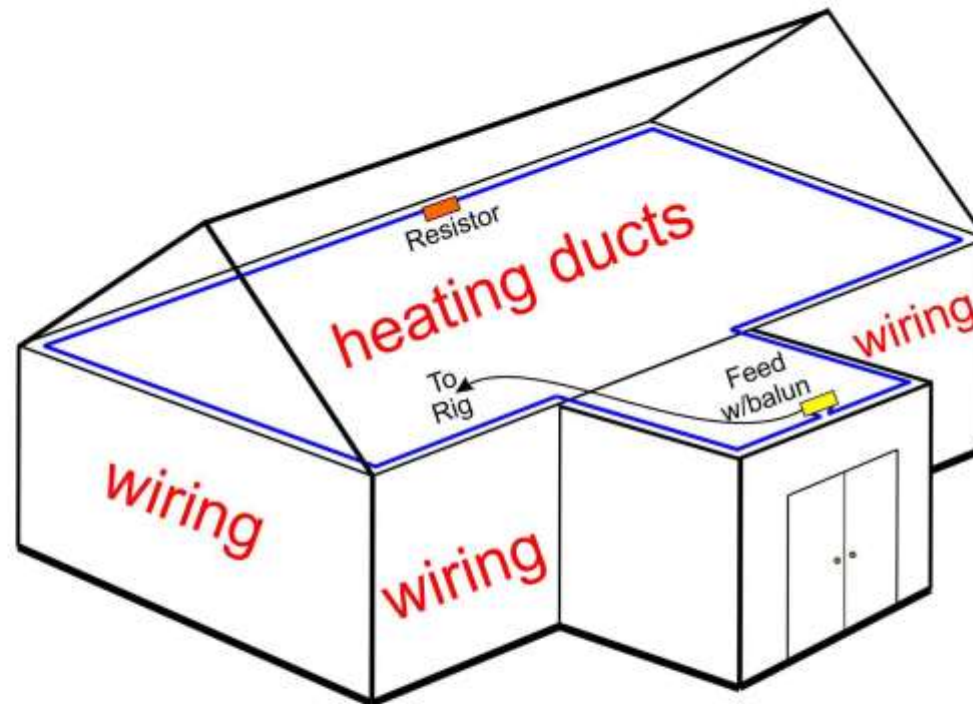


**One can find several suggestions on-line for
“home” antennas,
along with various claims.**

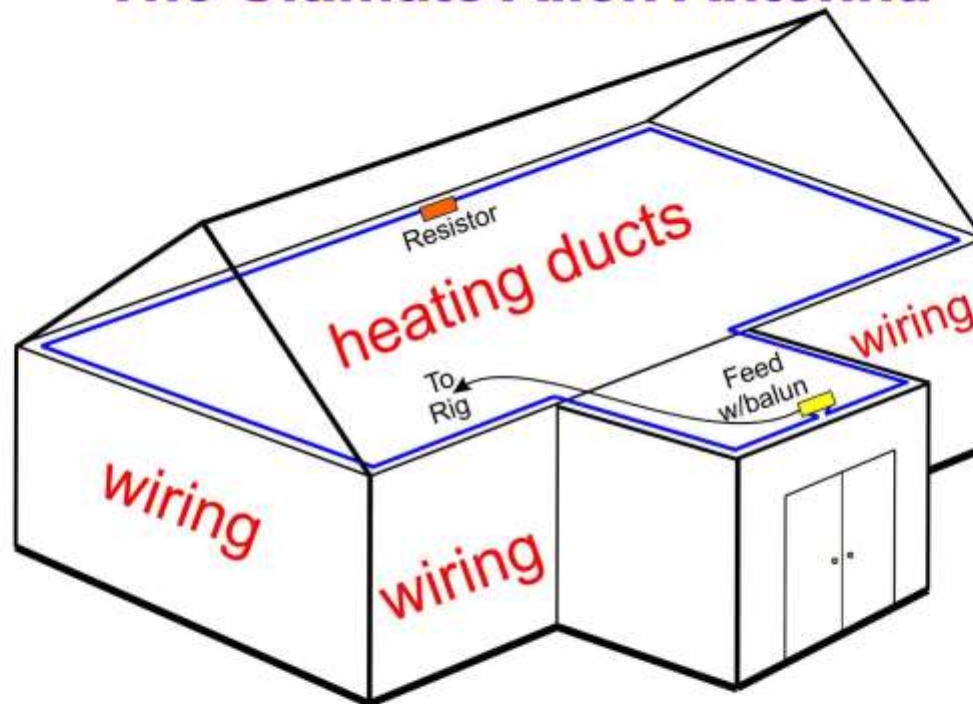
Here's one...







The Perimeter Antenna Lights up the entire house with RF “The Ultimate Alien Antenna”



House metal siding, or stucco
Gutters and down spouts
Security and sensors
Computer ethernet
Telephone lines

A word of CAUTION



Antenna High Voltage

Attic dipoles: → high voltage is at the ends can start a fire
→ ends of all dipoles are high voltage

Verticals: → roof-top radials can have high enough voltage to ignite wood shingles
→ horizontal resonators (like on a Bravo), high voltage is at the tips

Magnetic Loops: → high voltage is opposite the feed point and is very high

“Perimeter wires”: → can have multiple voltage maxima, depending on the length

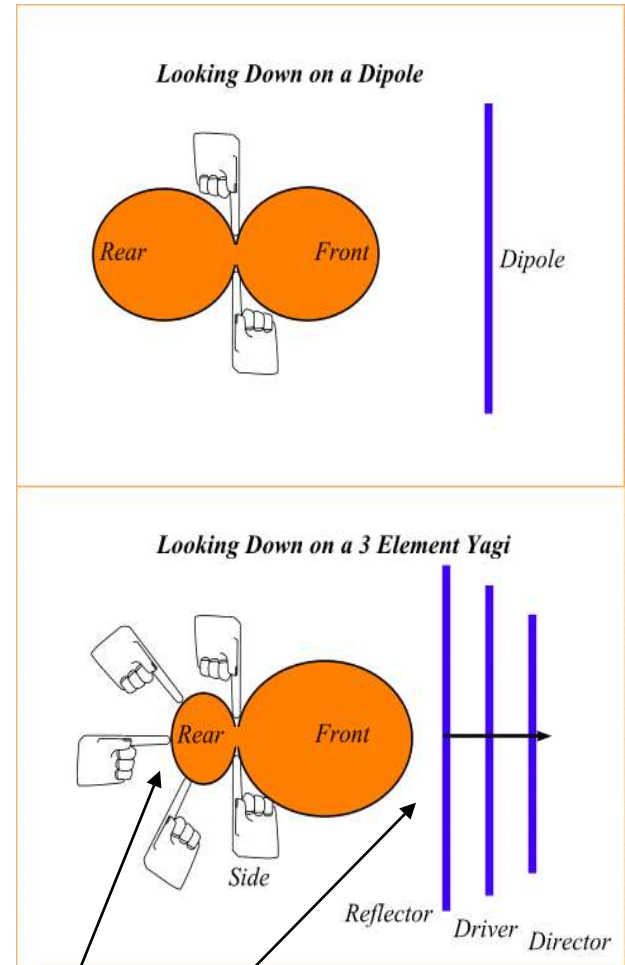
How do you *intentionally* get directivity?

By re-distributing/re-directing the energy.

The pattern is now directive, favoring one direction

at the expense of other directions.

Original dipole.



3-element Yagi

It will have gain over a dipole, or dBd

(the trailing "d" means dipole).

The way forward -- carefully plan
which antenna(s) to choose,
where to place them

and have reasonable expectations of the results.

Adding lots of antennas, particularly wires,
will not result in an effective system.

In general, less is better.

The lower power we run, the more
important our antenna.

Especially true on the low bands.

What's the most improvement (for the smallest investment)?

Adding one more element:

Either phased or parasitic,
this will add between 3 and 4.5dB over the single element.

Team Vertical will all affirm that 2dB is a “ton.”

Whenever we could find 2dB, we would do it, because:
it adds another layer of stations to work.

If you want to lay down
an antenna when it is not
in use,

*this vertical has a base
with a wireless actuator
that raises and lowers it.*





If you have an antenna like this
and do not want to lay down
ground radials,

use concentric open rings
7 bands, 40 – 10 and gain efficiency

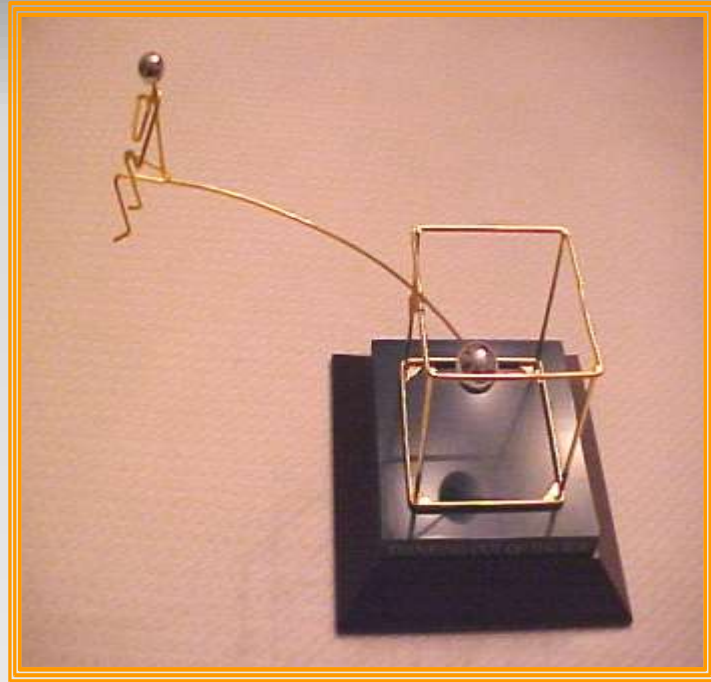


Thoughts for the day:

“Everything Works”

...and...

Think out of the box

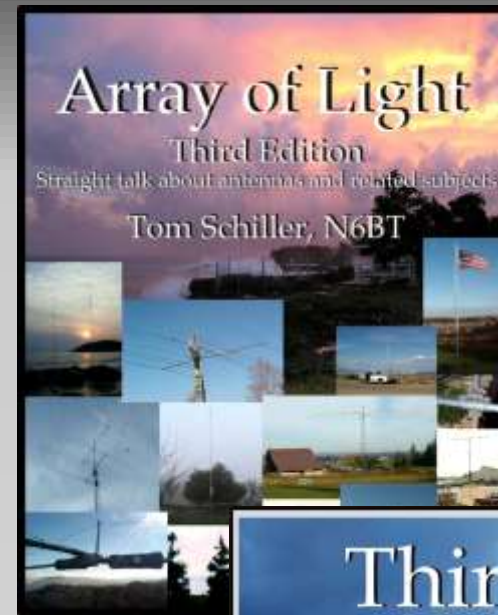


Want the most gain for your station? Try FT-8...

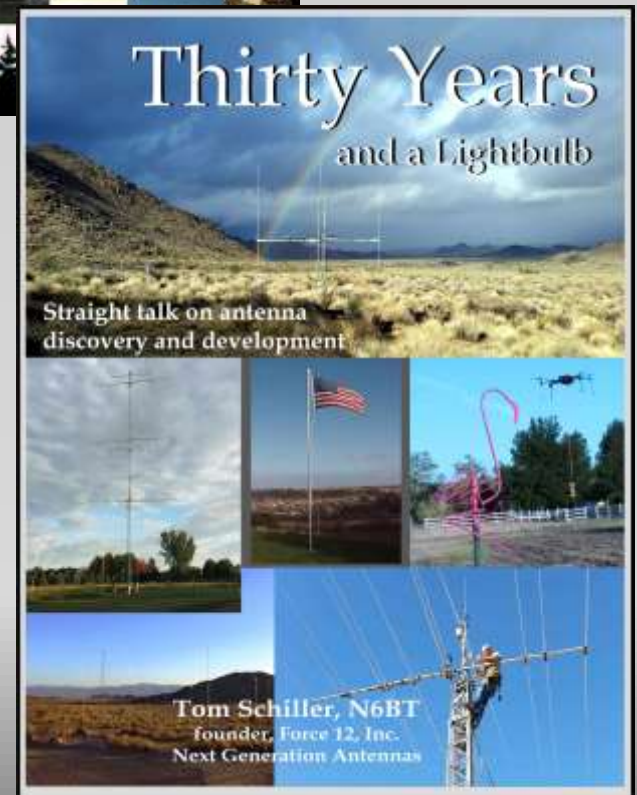
A.R.R.L. says the majority of QSO's in 2020 were digital.

The future of amateur radio is the youth.





*Available
on line*



Release coming soon

